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Effective Elements of Science Teacher Professional Development

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EFFECTIVE ELEMENTS OF SCIENCE TEACHER PROFESSIONAL DEVELOPMENT

by

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ABSTRACT
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Educational reform efforts to improve students' learning outcomes are often present in teacher professional development opportunities; however, the structure and design of these opportunities vary and often focus on a homogenous student population; that is, White students in suburban schools. Reform efforts in teacher professional development that aim to educate teachers not only about science content and pedagogy, but also about practices that aim to reach a diverse student population is needed. This study examines three, science teacher summer professional development (PD) programs [SUN, SEPA, and CLA], and explores how programs affect teacher learning outcome(s) and any subsequent translation into classroom practice(s). The design and delivery, alignment to Ladson-Billings (1994) tenets of culturally responsive practices, and measurement(s) of teachers' learning outcome(s) are evaluated. Fliers were sent to science teachers who participated in SUN, SEPA, and CLA in an effort to recruit volunteers for this study. Program document analysis and teacher post-survey data from each program, focus groups, evidence of program integration, and a culturally responsive practice survey were collected and analyzed. Results show SEPA to include content knowledge (CK), pedagogical content knowledge (PCK), culturally responsive practices (CRP), and some

elements of the conceptual change model (CCM) (Larkin, 2012) in program design, structure, and delivery along with translation into classroom practice. SUN and CLA both show incorporation of CK and PCK, with SUN also showing some evidence of CRP. The findings indicate that when teachers are modeled a practice they are able to translate that practice in their classroom. The potential impact of modeling CRP during science teacher PD may address the achievement gap still present among students of color. Program designers must consider the inclusion of CRP alongside CK and PCK during the development of science teacher PD.

This work is dedicated to my eldest daughter, Mikayla, and to my second daughter, Madelyn – who has not yet arrived at the time of my defense. It is also dedicated to my mom, dad, and sister, Janine, for all of their encouragement and support. Thank you!

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Introduction

He has the power. He identifies The Problem. The Problem resides in the home. The Problem resides within the nuclear family. The Problem resides with the parents. He identifies a solution: create a family he knows, “precisely as [he] did, observ[ing] the same rituals, and react[ing] to events in the same way” (Greene, 2000, p.21). He provides money to programs. He sets up daycares and tutoring centers. He hands out free laptops and picture books. He solves The Problem.

The child goes to school. The child is provided a textbook; missing from the textbook are examples from his/her own culture. The child is handed a standardized list of content to master, rather than being provided with ways to experience the content and make meaning of the words. The child takes an assessment, one created by followers of eugenics (Davis & Martin, 2008). The child does not read the textbook. The child does not understand the content or the words. The child fails the assessment. Did he solve The Problem?

In a school system where students commonly draw a stereotypical, White male scientist on a Draw-a-Scientist Test (Barman, 2006), science education is an essential content area to explore when aiming to address the cultural power imbalance within schools. The subculture of science requires a “defined system of meaning and symbols,” which may hinder students from pursuing the field as a viable career option (Aikenhead, 1996, p.8). Urban students, in particular, face challenges of “low…performance in reading and mathematics, high…mobility rates, chronic absenteeism and unmet psychosocial development” (Comer & Maholmes, 2010, p.5). An achievement gap in science education remains between Hispanic and White students, and between Black and

White students – with White students scoring higher on average on national assessments (NAEP, 2011). Efforts done thus far to counter the achievement gap between urban students and White students include the government's investment in programs that replace the role of parents rather than assessment and elimination of physical, human and social barriers operating within urban communities (Greene, 2000), are not working (Xu, Coats, & Davidson, 2012; NAEP, 2011). Quality science education is missing from the urban school system (Tate, 2001).

Traditional methods of instruction do not show the significant gains in student learning outcomes that alternative methods, such as constructivism and culturally responsive pedagogy, show (Smith, Maclin, Houghton et al., 2000; Brunkhorst, 1992). University professors find students who have been exposed to traditional methods – even those who have passed university exams – still retain conceptual misconceptions of the science topics studied (Prosser, Trigwell, & Taylor, 1994). In comparison, classrooms based in constructivism, where students experience the content through connections with their own, real-life experiences, show increased learning outcomes (Smith, Maclin, Houghton et al., 2000; Brunkhorst, 1992). Constructivist, learner-centered lessons capture student interest in the content being studied (Darden & Richardson-Jones, 2003). More recently a study by Fayon, Goff, & Duranczyk (2010) highlights the need for science teachers to not only engage in constructivist, learner-centered practices, but also to connect to student experiences within their community, which has close ties with culturally responsive practices (CRP). Science teachers must now be aware of the importance of using culturally responsive teaching practices, especially when encouraging more urban students to enter the field of science (NRC, 2012).

CRP is an important aspect of education often missing from the urban landscape (Ladson-Billings, 1994). The goal of CRP, to "facilitate student learning by capitalizing on the students' own social and cultural backgrounds," may address the achievement gap in education (p.10). Aspects of culturally responsive teaching include:

> (1) "students whose educational, economic, social, political, and cultural futures are most tenuous are helped to become intellectual leaders in the classroom" through utilization of the strengths brought by all students to the classroom,
>
> (2) "students are apprenticed in a learning community rather than taught in an isolated and unrelated way" so that students are exposed to a myriad of viewpoints, not just that of the academically elite (Aikenhead, 1996),
>
> (3) students' real-life experiences are legitimized as they become part of the "official" curriculum,"
>
> (4) "teachers and students participate in a broad conception of literacy that incorporates both literature and oratory," thus capitalizing on alternative forms of assessment,
>
> (5) "teachers and students engage in a collective struggle against the status quo" whereby students are made aware of societal injustice(s) and provided with methods to address them, and
>
> (6) "teachers are cognizant of themselves as political beings" whereby awareness of personal biases through personal reflection lead to more culturally relevant practices in the classroom (Ladson-Billings, 1994, pp. 117-118).

However, guaranteeing that science teachers have been trained in culturally responsive pedagogy is a challenge. More often than not, science teacher certification programs across the nation that aim to prepare teachers for urban schools have a range of requirements (Roehrig & Luft, 2006).

Roehrig & Luft (2006) compared four science teacher preparation programs through first-year teachers' participation in an induction program. Teacher participants demonstrated an array of abilities as they reflected upon, and sought support throughout their first-year teaching. The amount of science methods coursework, fieldwork experience(s), and culturally responsive pedagogy are three examples of aptitude that varied (Roehrig & Luft, 2006). What is clear from Roehrig & Luft's (2006) study is that all science teacher certification programs are not equal. In fact, the range in requirements assessed by science teacher certification programs opens the door for in-service professional development (PD) programs to model culturally responsive practices. Science teacher PD that addresses the problems faced by teachers working in urban schools may have the effects of PD manifest in urban youth (Johnson & Fargo, 2009).

This study explores science teacher professional development programs' effects on teacher learning outcomes through a lens of culturally responsive practices (CRP). The study also examines differences in program structure and objective(s) in relation to the following research question: How do science teacher summer professional development programs affect teacher learning outcome(s) and any subsequent translation into their classroom practice(s)? Attendant questions include:

1. How does the design and delivery of science teacher summer professional development programs, namely SEPA at UW-Milwaukee, SUN at

M.S.O.E., and CLA at UW-Madison, shape what teachers learn and any subsequent translation into classroom practice(s)?

2. How do science teacher summer professional development programs (SEPA, SUN, and CLA) align with Ladson-Billings (1994) tenets of culturally responsive practices?
3. How are teachers' learning outcomes measured by the summer professional development programs (SEPA, SUN, and CLA)?

The science teacher PD experiences chosen for this study SEPA, SUN, CLA range from a weekend workshop, to a two week-long, collaborative learning environment with University support throughout the following school year. All three programs have a common focus on science content learning and pedagogy. The findings of this study will provide insights around both program structure and objectives for developers of science teacher PD. Perhaps, through examination of each programs' alignment to culturally responsive practices as well as teacher learning outcomes, future programs will consider the inclusion of culturally responsive modeling a vital aspect of PD design.

The literature review looks at the historical role standards have played into the practices of science educators, and examines future implementation of the Next Generation Science Standards. It surveys exemplary science educator practices, namely constructivist and culturally responsive methods in relation to urban youth. Connections are made between current methods of science teacher PD and the need to address gaps present in science teacher education. Finally, methods of measuring change in culturally responsive teaching practices is examined with Larkin's (2012) Conceptual Change Model (CCM).

The methodology of this study uses inferential statistics to examine relationships between science teacher PD experiences and teacher learning outcome(s). A correlation between the degree of culturally responsive PD program structure (i.e. alignment of PD to Ladson-Billings (1994) tenets of culturally responsive practices) and teacher-learning outcomes is also explored. Focus groups and surveys concerning teachers who participated in SEPA, SUN, and CLA will be analyzed for content learned – including culturally responsive practices. If the degree to which culturally responsive practices integrated within science teacher PD is correlated to high levels of teacher learning outcome(s), then Ladson-Billings' (1994) tenets should be incorporated into the design of in-service science teacher PD. This study provides insight into science teacher PD by comparing teacher learning outcomes to program design and alignment to culturally responsive practices.

Teacher professional development (PD) is a significant aspect of school science reform in the United States (Garet, Porter, Desimone, et al., 2001). Constructors of effective teacher PD programs must read the literature to find successful and unsuccessful methods of program structure and analysis so that teachers can experience programs that will lead to significant gains in their own learning, as well as possible learning gains for students (Garet, Porter, Desimone, et al., 2001). The National Research Council (NRC) recognizes the importance of culturally responsive methods, and calls for equity in the quality of education offered to *all* students (NRC, 2012). However, even with research showing gains and government acknowledging practices, science teacher PD tends to focus on the science (Johnson & Fargo, 2009). Furthermore, while much is learned through qualitative studies (Calabrese Barton & Yang, 2000), quantitative research

provides correlations that often go unexplored in educational research. Effective PD can lead to substantial changes in teacher knowledge and in student learning (Batiza et al., 2013), but the qualities of effective PD remain disputed. “Relatively little systematic research has been conducted on the effects of professional development on improvements in teaching or on student outcomes” (Garet, Porter, Desimone, et al., 2001, p.917). Many PD opportunities claim to cause change in teacher and student learning, but their statements are based on faulty research designs that do not have accurate or consistent methods of measurement (Garet, Porter, Desimone, et al., 2001). “Although some researchers are beginning to examine the effects of professional development on teaching and learning, few studies have explicitly compared the effects of different characteristics of professional development” (Garet, Porter, Desimone, et al., 2001, p.918).

Student learning is directly tied to teacher effectiveness (Cone, 2009). To ensure quality science education for *all*, science teacher PD has to implement structure(s), objective(s), and design(s) identified in scientifically valid and reliable research reports to be effective. For NGSS (NRC, 2012) to be realized, change has to take place in the analysis, and interpretation, of PD data.

Chapter 1: Literature Review

In this study, urban is a term used to identify students, schools, and communities that are located in large, metropolitan areas which house a large proportion of individuals from low socioeconomic status (Calabrese Barton, Drake, Gustavo Perez, et al., 2004). Urban schools serve, in large part, academically disadvantaged families who are often poor and of color. In contrast, according to the National Center for Education Statistics (2012), 3.3 million full-time, public school teachers are at work in the United States – 83% white and female (U.S. Department of Education, 2010). The majority of urban teachers are “inexperienced middle-class White European Americans” (Brown, 2004, p.267), who do not understand the needs of the student body they serve – that is, incredibly diverse, and “disproportionately poor” students of color (Atwater, 1995, p.22). Science teachers, in particular, must connect with urban youth because many minority students do not view the fields of science and engineering as “viable career options” (Atwater, 1995, p.22). With the achievement gap between urban students of color and White, suburban students widening, it is evident that many existing reform efforts in urban education are not working (Xu, Coats, & Davidson, 2012). Because student achievement is directly tied to teacher effectiveness (Bleicher & Lindgren, 2005), there is a need for science teacher education programs to examine practices that prepare teachers for urban settings. Science teacher education programs and in-service PD can no longer address just the science – they must also address the challenges of teaching at urban schools.

This literature review addresses five areas: (1) the historical relevance of science education standards to classroom practice; (2) the right for all students to learn science;

(3) the effectiveness of constructivist and culturally responsive pedagogy in the classroom; (4) the challenges of science teacher PD in urban settings; and, (5) methods of evaluation to measure change in culturally responsive teaching practices.

Historical Relevance of Science Standards to Classroom Practice

The launch of Sputnik in 1957 started reform movements in the United States that focused on enhancing science education (Collis, 1997). Due to growing concern about declining science achievement scores in the United States, a wave of reform efforts in the 1980s further attempted to shift the focus of science education towards inquiry practices (Collins, 1997). A need to standardize students' science education became a movement wherein it become inherent to make sure that all schools were held accountable for teaching science content in its entirety (Collins, 1997). Reform efforts encouraged students' "learning science as an active process rather than having students passively memorize terms and formulae" (Collins, 1997, p.300). In 1977, Norris Harms published a report that synthesized science educational research findings from the preceding decades (Yager, 2004). Four goals were identified for school science, and three of these goals were retained in National Standards that were released in 1996 (Yager, 2004). Interestingly, "the academic preparation goal that framed Project Synthesis [was] not included" in standards that followed (p.23). Historically, the National Science Education Standards (NSES) served the role of achieving *science for all* (Collins, 1997). The four goals of NSES include turning out students who can:

1. experience the richness and excitement of knowing about and understanding the natural world;

2. use appropriate scientific processes and principles making personal decisions;

3. engage intelligently in public discourse and debate about matters of scientific and technological concern; and,

4. increase their economic productivity through the use of knowledge and understanding, and skills of the scientific literate person in their careers. (NRC, 1996, p.13)

Presently, a new set of science standards have been released, the Next Generation Science Standards (NGSS). Based on research that came out of NSES, NGSS aims to be another step towards excellence in science learning in the classroom (NRC, 2012).

Project Synthesis & Four Goals Clusters. Norris Harm's Project Synthesis Study (1977) identified Science-Technology-Society (STS) curriculum as one of the areas lacking in school science curriculum (Yager, 1996). Project Synthesis' goal was to analyze educational research to search for excellence in science teaching, organized around four goals clusters, including: "science for meeting personal needs…science for resolving current societal issues…science for assisting with career choices…[and] science for preparing for further study" (p.5-6). Figure 1.1 shows these four clusters.

Goal Cluster	Description
Science for meeting personal needs	Science education prepares students to use science to improve their own lives and an increasingly technological world
Science for resolving current societal issues	Science education produces informed citizens to deal with science-related societal problems in a responsible way
Science for assisting with career choices	Science education makes all students aware of the possibilities of science-related career choices
Science for preparing for further study	Science education prepares students to

	pursue science – professionally and personally

Figure 1.1. The Four Goals Clusters.

STS curriculum's focus on real-world issues begins with a "question, problem, or issue" that students explore through engagement with science concepts (p.10). Students further develop questions that analyze the topic at hand and learn both content and process skills (p.10). The results of Project Synthesis led to a greater focus on inquiry education and the formation of National Science Standards (Yager, 2004). STS curriculum became a part of the standards, but was challenging to implement because of traditional, direct instruction dominating most science classrooms. Yager (1996) identified the need for pre-service and in-service science teacher training in STS methods. Unfortunately, a focus on state test results led to insufficient use of STS curriculum in the science classroom and the four goals clusters proposed by Harms (1977) have yet to be realized in schools across the Nation (Weiss, Banilower, McMahon, et al., 2001).

NSES. In 1993, organization of science content by grades "K-4, 5-8, and 9-12" were put in place as well as the beginning development of science standards (Collins, 1997). In 1995, the National Science Education Standards (NSES) were released and described as a "vision of science education," emphasizing "teaching science for understanding through inquiry" (p.303). The goal of inquiry-based learning was to develop "well-structured science subject matter knowledge and the ability to reason and to apply science understanding to a variety of problems" (p.305).

STS was incorporated into NSES standards –students were to participate in community-based projects through which they gain knowledge of the content area (Yager, 1996; Collins, 1997). Teachers were expected to incorporate "personal and social

perspectives…[an]… understanding…[of]…personal and community health issues, human population growth, natural resource management, and environmental quality, and natural and human-induced hazards" (Collins, 1997, p.306). NSES recognized the need for STS curriculum and did not acknowledge the learner to have grasped the content unless he/she was able to apply concepts outside the classroom (p.306). NSES also required students to complete "one full inquiry each year" (p.305) – the type of open inquiry identified by Herron (1971).

Herron's (1971) four levels of inquiry include: (1) Confirmation/ Verification – students know the results of an experiment in advance and are confirming knowledge learned through lecture (as implied by the label, not inquiry; rather, a practice in the classroom), (2) Structured Inquiry – students are asked to develop a solution to a problem and procedure provided by the instructor, (3) Guided Inquiry – students develop a procedure and solution after presentation of a problem from the instructor, and (4) Open Inquiry – students develop a problem, procedure, and solution based on their own curiosity of a topic. Figure 1.2 summarizes Herron's four levels of inquiry.

Level of Inquiry	Who Proposes the Problem	Who Proposes the Procedure	Who Proposes the Solution
Confirmation	Teacher	Teacher	Teacher
Structured	Teacher	Teacher	Student
Guided	Teacher	Student	Student
Open	Student	Student	Student

Figure 1.2. Four levels of inquiry.

Herron (1971) encouraged educators to be flexible in the level of inquiry used with students, especially across science disciplines of biology, chemistry, and physics, because the levels of inquiry reached in certain disciplines may vary (p.174). How teachers addressed the remaining science content with their students, outside of the inquiry

experience(s), was at the teacher's discretion. Inquiry practices were strongly encouraged with the NSES framework (NRC, 1996).

Because of the vast amount of science knowledge, and the limits on classroom time as a result of inquiry-based learning activities, NSES focused on content that was determined to be fundamental to science (Collins, 1997). Many topics that were found in science textbooks were left out of NSES, and some science topics were re-assigned to different grade levels in an effort to make science teaching manageable with the time commitment to inquiry (p.306). Inquiry-based curriculum, even inquiry-based curriculum utilizing an STS approach that favors "the enculturation of students into their local, national, and global communities," encourages students to address the needs of their local community (Aikenhead, 2997, p.16). Research surrounding the implementation of NSES' inquiry and STS approach has shown progress in student learning outcomes and provided insight into the major changes have taken place in the world of science since the standards were implemented (NRC, 2012). In 2013, the Next Generation Science Standards (NGSS) were introduced as a new set of teaching standards that are, in large part, based on the research surrounding NSES.

NGSS. Inquiry-based learning dominates the new science standards, and focuses on student performance expectations as outcomes to student learning (NRC. 2012). The shift from content to performance assessments is a key trademark of NGSS (NRC, 2012). Performance expectations identify the vision of student understanding for students at each grade level – what students will know and be able to do with that knowledge (NRC, 2012). Each standard area begins with "students who demonstrate understanding can…" (NRC, 2012), and follows with Practices, Content, and Concepts that support student

achievement in the area. Practices involve aspects of scientific and engineering design, Content involves the information students should learn, and Concepts involves the themes that transverse classroom units and areas of study (NRC, 2012). Figure 1.3 provides two examples from the Life Sciences of performance expectations that are present in NGSS, and identifies how performance expectations are connected to the science and engineering practices, core ideas, and crosscutting concepts (NGSS Release HS-LS1, 2013):

Performance Expectation	1. "Use a model to illustrate the role of cellular division (mitosis) and differentiation in producing and maintaining complex organisms." (HS-LS1-4) 2. "Use a model to illustrate how photosynthesis transforms light energy into chemical stored energy." (HS-LS1-5)
Science and Engineering Practice	1 & 2. "Use a model based on evidence to illustrate the relationships between systems or between components of a system."
Core Idea	1. "In multicellular organisms, individual cells grow and then divide via a process called mitosis, thereby allowing the organism to grow. The organisms begin as a single cell…that divides successively to produce many cells, with each parent passing identical genetic material…to both daughter cells. Cellular division and differentiation produce and maintain a complex organism, composed of tissues and organs that work together to mee the needs of the whole organism" 2. "The process of photosynthesis converts light energy to stored chemical energy by converting carbon dioxide plus water into sugars plus released oxygen."
Crosscutting Concept	1. "Models…can be used to simulate systems and interactions – including energy, matter, and information flows – within and between systems at different scales." 2. "Changes of energy and matter in a system can be described in terms of energy and matter flows into, out of, and within that system."

Figure 1.3. Life science example of performance expectations in NGSS.

NGSS’ incorporation of science and engineering practices into student performance expectations places engineering practices at the same level of importance as scientific inquiry (NRC, 2012). Engineering practices encourage the design element of inquiry that is often left out of inquiry-based lessons (Minner, Levy, & Century, 2010). Engineering practices provide an outlet for STS engagement since students must be able to apply the knowledge they learned to real-world contexts at each level of the standards (NRC, 2012). In comparison, STS curriculum was encouraged with NSES, but not embraced by educators as effectively as science content and assessment standards were embraced (Collins, 1997). NSES’ science concepts were presented as disjointed facts that students needed to know, not a consistent progression of understanding (NRC, 2012). NGSS identifies what content students should learn at each grade level, and focuses on what students can do with the knowledge. The science and engineering practices, content, and concepts are reinforced over time. For example, the science and engineering practice of modeling abstract concepts is repeated for the 6-8 grade levels and the 9-12 grade levels. The shift in focus from inquiry (NSES, 1996) to inquiry and engineering (NRC, 2012) will either be intimidating or receptive to science teachers who must implement the standards.

Just as Yager (1996) suggested should take place with STS curriculum, PD opportunities that help educators understand how to implement NGSS will greatly enhance the success of NGSS’ integration into K-12 classrooms. Perhaps, including teacher performance expectations – demonstration of PD integration with students – can serve as a method of measurement for teacher learning outcome(s) with the PD experience. Nonetheless, whether or not NGSS’ incorporation of engineering practices

will address the achievement gap between majority and minority students, particularly in urban schools, in science education remains to be seen.

Including the excluded. With urban students currently falling behind on national assessments, one wonders what effect NGSS will have on their science classroom experience. Are the science and engineering practices identified by NGSS that utilize an STS approach through inquiry methods enough to draw marginalized youth into the field of science? Johnson & Fargo (2009) note, “urban students, who are predominantly from minority and low socioeconomic status, experience less effective teaching in less than supportive learning environments and fall behind their counterparts in other schools” (p.3). A lack of science education leaves urban youth out of science and engineering career pathways, and creates a barrier for these students when competing for high-quality jobs (Johnson & Fargo, 2009). Changing content and pedagogy from teacher direct instruction and content memorization to inquiry-based and learner-centered methods, where students question the merits, origin, and importance of knowledge – particularly that which is traditionally excluded – begins to address the disparity. PD that addresses the importance of science education for all and stresses the need for a shift in teaching from traditional to constructivist methods has the potential to cause significant change in student learning outcomes (Smith, Maclin, Houghton et al., 2001).

One of the main focuses of NGSS is a framework for science expectations in K-12 classrooms that centers on inquiry-based learning (NRC, 2012). However, past standards also focused on inquiry-based learning and were not implemented the way the standards intended (NRC, 1996); a historical look at reform efforts promoting inquiry-based learning in K-12 science education provides insight into the challenges teachers

face with incorporating inquiry into classroom practices and suggests teacher PD that models use of its methods as well as other practices that aim to include the traditionally excluded.

Past science standards, including: Science For All Americans (SFAA), the Benchmarks for Science Literacy, and the National Science Education Standards (NSES) promised science and/or scientific literacy for all Americans (AAAS, 1990; AAAS, 1993; NRC, 1996). Measures were taken with No Child Left Behind (NCLB) legislation (U.S. Department of Education, *Title I: Improving the Academic Achievement of the Disadvantaged*) to ensure that measurements were in place to hold schools accountable to that goal. However, the unintended consequences of NCLB have now been realized and state testing dominates most of the time urban youth spend in classrooms across the nation (Bleicher & Lindgren, 2005). Care was taken so that state testing does not cloud the focus of NGSS' implementation, and that teachers receive PD that ensures an understanding of the standards' focus on conceptual understanding, skill building, and inquiry learning (Smith, Maclin, Houghton et al., 2001).

When President George Bush signed No Child Left Behind (NCLB) legislation into law in 2002, many urban elementary schools shifted their focus to English and mathematics because of state assessments' focus in these areas (Johnson & Fargo, 2009). This was done because school funding depends on state test results, and as a result, many urban youth did not experience science education until middle school. This situation is complicated by the fact that African-American children living in poverty often drop below grade level during their elementary school years (Brown, 2001); further, "African American males rank lowest in virtually every academic measure" (Hopkins, 1997, xii).

Falling behind in science – an achievement gap – widened between minority students in the city and privileged, White students in the suburbs.

President Obama reformatted NCLB, and offered Race to the Top (RTTT) as an optional program for states, schools, and districts so they could apply for grant money to measure individual student, teacher, and school performance (Lohman, 2010). This change, along with the recent change in science standards from NSES' content and inquiry-based focus (NRC, 1996) to NGSS' inquiry and skill-based focus (NRC, 2012) requires PD for science educators at all levels – elementary through high school – so that teachers understand the importance a science education has on student development (Bybee, 2013; Smith, Maclin, Houghton et al., 2001). Because there is no current accountability measure in place regarding NGSS implementation, care has to be taken so the unintended consequences of NCLB do not occur with NGSS.

The Common Core State Standards (CCSS), which, to date, focus on English and mathematics, were recently implemented in schools across the nation, primarily through RTTT funding. CCSS accountability measures include: ASPIRE and ACT testing. And, while NGSS' framework is aligned with CCSS, whether or not PD will successfully educate teachers about the importance of science education and the cross-curricular advantages of bridging NGSS with CCSS remains unknown. One hopes that science education will not, once again, be left out of elementary education for urban youth simply because science content is not directly addressed on CCSS assessments. Urban students bring with them a wealth of information and resources that must be utilized in the classroom. Educators must be aware of the importance of science education on students at every grade level as well as how to gain access to resources within a school's local

community so that if funding for science fails, exposure to science education does not (Smith, Maclin, Houghton et al., 2001). PD that works to expose how science education can be integrated with English and mathematic education will help bridge CCSS and NGSS, and potentially provide new outlets for educators to explore science at all grade levels. The new standards also encourage the strengthening of school/community partnerships.

NSES, NGSS, & school/community partnerships. NGSS identifies the importance of school-community partnerships: "it is through…[school-community partnerships]…that students who have traditionally been alienated from science recognize science as relevant to their lives and future" (NGSS Release, *Appendix D – "All Standards, All Students,"* 2013, p.9-10). NSES also supported STS curriculum that includes addressing community issues (Yaeger, 1996). When school resources are limited for science education, utilizing community resources may help students cross into the subculture of science (Aikerman, 1996). Home-school connections are important for urban youth who do not see their connection to, or the importance in, science without explicit discussion. PD that provides science teachers with networks to the local community encourages students to see the role of science in their own world and begins to incorporate elements of culturally responsive practices (CRP) (Ladson-Billings, 1994).

NGSS encourages learning at all levels, from student exploration of the community to bringing community members to the school, to developing "critical consciousness of social inequities" within their community (NGSS, *Appendix D – "All Standards, All Students,"* 2013, p.10). Urban youth, living in poverty, greatly rely upon school resources for physical capital and the supplies those monies bring to their school

such as textbooks, computers, and lab equipment, often do not have the funding from home found with suburban students. Urban youth gain immensely from community outreach (NRC, 2012; Comer & Maholmes, 2010; Basu & Calabrese Barton, 2006). Physical capital that can be offered by local businesses to supply urban youth with books and technology helps; however, a pedagogical understanding of how to reach urban youth (human capital) with CRP and knowledge of community outreach (social capital) is essential to urban school reform (Tate, 2001). More awareness has to be made in teacher education programs as well as in science teacher PD about the importance of constructivist and CRP so that urban youth have access to all forms of capital (Spillane et al., 2001).

Constructivist Practices in the Science Classroom

While inquiry education is known to be "valuable for many underserved and under-represented populations" (Haury, 1993, p.3), it is not often used in such classrooms (Davis & Martin, 2008). When White, middle-class teachers enter diverse, urban schools, they often return to what they know and are comfortable with – direct instruction (Cone, 2009). African-American students have continually been exposed to such practices as 'teaching to the test' as a "dominant instructional approach," emphasizing "remediation, skills-based instruction…decreased use of rich curriculum materials, narrow teacher flexibility in instructional design and decision making, and the threat of sanctions for not meeting externally-generated performance standards" (Davis & Martin, 2008, p.11). The biggest barriers to utilizing inquiry education are the pressure to deliver quality state-test results, and a lack of teacher educators modeling inquiry during science methods courses (Burton & Frazier, 2012).

Hands-on science observed with inquiry learning was exemplified in the 1960s (Wilson & Chalmers-Neubauer, 1990). In the 1980s, teachers were instructed to employ its methods (Wilson & Chalmers-Neubauer, 1990). Project Synthesis identified the four goals clusters to focus on, including: personal needs, societal issues, academic preparation, and career education/awareness (Project Synthesis, n.d.). Today, it is known that to expect constructivism to enter classrooms, teacher educators must model it to teacher candidates during pre-service education courses (Cone, 2009). A teacher's belief in his/her ability to help students understand science content is directly related to the teacher's choice of practice, and a teacher's choice of practice is directly tied to how he/she was taught in school and what practices were modeled and reflected upon during pre-service education (Cone, 2009). Examples of teacher practice and effects on student learning gains are noted throughout the literature; research that shows the importance of inquiry science education are observed in studies by Smith, Maclin, Houghton et al. (2000), Darden & Richardson-Jones (2003), and Brunkhorst (1992).

Smith, Maclin, Houghton et al. (2000) document a case study of Dr. Hennessey's elementary classroom where first through fifth grade, White, middle-class students develop "knowledge problematic epistemology" through enrollment in a constructivist science classroom (p.357). Students in Dr. Hennessy's classroom were encouraged to "devise and test their emerging theories" (Smith, Maclin, Houghton et al., 2000, p.358), "pursue personal understanding and meaning making" (p.361), "reflect on the intelligibility, plausibility, and fruitfulness of their ideas" (p.363), and "exchange…views, classroom dialogue, and develop…shared norms" (p.387). Significant findings show that the elementary students experiencing a constructivist

classroom develop skill sets unnoticed in the traditional classrooms, including: testing, understanding and developing ideas (p.369), understanding the role of complex evidence in investigations (p.377), providing better explanations for choices, and understanding that prior ideas can constrain progress in science (p.377). Gains such as those observed in Dr. Hennessy's classroom with elementary students who were not expected to achieve high intellectual development (Carey and Smith, 1993) bring to question urban administrators and teachers who doubt the abilities of urban youth (Spillane et al., 2001).

Furthermore, Brunkhorst's (1992) study of exemplary Middle and Junior High School Programs connects exemplary science programs to exemplary science teachers and the pedagogy embraced in their classroom. By spending 91% of class time with hands-on activities and only 21% of class time with lecture, exemplary science teachers encourage their students to ask questions and share ideas (Brunkhorst, 1992, p.573-574). Results show students in the constructivist classroom excited about learning science and scoring higher on science knowledge assessments (Brunkhorst, 1992).

Darden & Richardson-Jones (2003) further support the idea of student-centered learning. Investigating the results of student learning of genetics, Darden & Richardson-Jones (2003) examine student exit-survey responses after being instructed in a learner-centered environment. Student survey responses "reinforced the necessary inclusion of a variety of instructional strategies within teacher preparation courses and content courses" (Darden & Richardson-Jones, 2003, p.106). While the study has a poorly structured methodology – lacking demographic information and statistical analysis from the participants in its report – an increase in student motivation to learn science through learner-centered practices is observed (Smith, Maclin, Houghton et al., 2000; Darden &

Richardson-Jones, 2003). Motivation is a critical factor in engaging urban youth who see the culture of science as a barrier to their success in the field (Emdin & Lee, 2012; Aikenhead, 1996).

Culturally Responsive Practices (CRP) in the Science Classroom

Capturing students' attention, and motivating students to connect with the curriculum takes place in constructivist classrooms that utilize an STS approach (Smith, Maclin, Houghton et al., 2000) and comes to fruition in culturally responsive (CEP) classrooms that encourage students to think critically about the world around them (Brown, 2004). "Culturally responsive pedagogy recognizes and utilizes…students' culture and language in instruction, and ultimately respects the students' personal and community identities" (Richards, Brown, & Forde, 2006, p.7). Figure 1.4 highlights methods educators can use to integrate CRP in their classroom.

Method	CRP (1) Explanation. (2) Example.
Acknowledgement of student differences and commonalities (p.8)	(1) Don't respond to students based on ethnic/racial stereotypes. "Ascrib[ing] particular characteristics to a student solely because of his/her ethnic or racial group demonstrates just as much prejudice as expecting all students to conform to mainstream cultural practices" (p.8) (2) A child from a cultural background that forbids eye contact with adults may or may not follow traditional practices. A teacher who follows a cultural stereotype without recognizing the student as an individual with unique needs commits prejudice against the child. Each student is unique.
Validate students' cultural identity in classroom practices and instructional materials (p.8)	(1) Classroom activities are used that are culturally supportive for students. (2) Supplemental activities are added to curricula that display diversity and that are sensitive to various backgrounds – not stereotypical. Students are given the opportunity to think differently, and feel included in classroom activities. Cooperative learning can be used to increase success for students because the strategy encourages students to explore different viewpoints. (p.8)
"Educate students about the diversity of the world around them" (p.8)	(1) Students are provided with learning opportunities that help them become more knowledgeable about other cultures as well as more comfortable when encountering people different from them. (2) Students interview people from other cultures. Students email people from other communities and/or cultures. (p.9)
"Promote equity and mutual respect among students"	(1) All students feel like they are treated fairly and equally. (2) Establish a clear and consistent management system in the classroom that does not discriminate against cultural practices. (p.9)
"Assess students' ability and achievement validity" (p.9)	(1) Assessment instrument(s) must be valid for the population being assessed. (2) Assessment instruments should be varied and suited to the population being tested, and they must be culturally sensitive. (p.9)
"Foster a positive interrelationship among students,	(1) Students bring knowledge from home to school and from school to home. Teachers must effectively bridge this home-community-school relationship. (2) Teachers must utilize community partnerships and participate in community events. (p.9-10)

their families, the community, and school"	
"Motivate students to become active participants in their learning" (p.10)	(1) "Teachers must encourage students to become active learners who regulate their own learning through reflection and evaluation" (p.10). (2) "Students set goals, evaluate their performance, utilize…feedback, and tailor…their strategies" (p.10). Inquiry-based learning.
"Encourage students to think critically" (p.10)	(1) Help students become independent thinkers (p.10) (2) Students analyze, synthesize, and view situations from multiple perspectives (p. 10); "what-if" scenarios from various viewpoints
"Challenge students to strive for excellence as defined by their potential" (p.10)	(1) Teachers hold high expectations for their students with appropriate assistance (p.10) (2) Teachers continually "raise the bar" to push students farther – helping all students reach their potential (p.10)
"Assist students in becoming socially and politically conscious" (p.11)	(1) Teachers prepare students to participate meaningfully and responsibly in the classroom and in society (p.11) (2) Students are encouraged to "critically examine societal policies and practices, and to work to correct injustices that exist" (p.11); students "write group or individual letters to politicians and newspaper editors voicing their concerns about specific social issues" (p.11); students "participate in food or clothing drives to help people less fortunate" (p.11)

Figure 1.4. Methods to integrate culturally responsive practices (CRP) in the classroom.

CRP aims to foster classroom environments where all students are valued for the contributions they bring to school, and where the learning environment is not mono-cultural in origin. Teachers must recognize and refrain from the biases they bring to the classroom regarding cultural and/or ethnic difference from the population they serve, and address any inequalities established within the curriculum (Ladson-Billings, 1994). NSES and NGSS connection to CRP through STS curriculum was developed, in part, through the work of science educators analyzing twenty years of education research on inquiry methods in the science classroom (Project Synthesis, n.d.). The four goals clusters that form STS curriculum are seen in CRP – evidence of this is found in school-community outreach projects that are apparent in both STS and CRP practices. Furthermore, NGSS address what science educators can do to make science education accessible to all, including acknowledgement that over the last 500 years science education has failed to incorporate historical contributions from non-European cultures; thus, further supporting CRP (NGSS Release, *Appendix D – "All Standards, All Students"*, 2013, p.4). Limiting the study of cultural viewpoints to calendar holidays like Black History month alienates urban youth and leaves them feeling isolated and detached from the school system (Banks, 1995). The placing of engineering practices into NGSS expose community-based problems and invites students of all backgrounds into the science conversation. Having students explore issues of societal injustice through the lens of science connects to both STS and CRP, and offers a multitude of knowledge gains, including: science content knowledge, science connections to real-life, and meaningful science process skills (Rodriguez & Berryman, 2002).

Aikenhead (1996) acknowledges “most students view orthodox science content as having little or no relevance to their life-world subculture” (p.12). Basu & Calabrese Barton (2006) confirms this view with a group of urban students living in poverty who identify science as boring because the curriculum does not connect to student interests or experiences (p.466). PD that addresses NGSS incorporation of engineering practices, which may ask students to design solutions to community-based problems, may move science educators away from an “arrogance of ethnocentricity” about science education (Maddock, 1981, p.13) towards culturally responsive classrooms that expose multiple truths of knowledge, biases, and interpretation from a myriad of viewpoints.

Ladson-Billings’ (1994) tenets of culturally responsive practices include methods that help students who do not have a background rooted in science or the cultural know-how of science to become “intellectual leaders in the classroom” as their real-life experiences are legitimized and integrated into the “official” curriculum” (pp.117-118). Furthermore, students and teachers that utilize CRP are “engag[ed] in a collective struggle against the status quo” (pp. 117-118). Culturally responsive practices are observed in short vignettes within the NGSS framework (Case Study 2, 2013); thus, CRP is suggested as having potential to cause significant change with student learning outcomes in urban settings (Smith, Maclin, Houghton et al., 2001; Aikenhead, 1996).

While NGSS address equity issues through culturally responsive teaching, whether or not conceptualization of equity by NGSS’ creators remains unclear as the standards address a transition that students will make “from…naïve conceptions of the world to more scientifically-based conceptions” (NGSS Release, *Appendix D – “All Standards, All Students”*, 2013, p.5). The “culture of power” (Delpit, 1988, p.282) that

resonates with the abovementioned statement, with assimilation of the subculture of science through culturally diverse students' *naïve* conceptions, fails to recognize students' ability to derive understanding from their own exploration of science content and the natural world. Nonetheless, NGSS' focus on identifying key practices leading to experiences that are "empowering and transformative, [encourage students] to embrace and further investigate what they [are] learning" (Basu & Calabrese Barton, 2006, p.468). NGSS further identifies aspects of culturally responsive teaching, including: "(1) value and respect [for] the experiences that all students bring from their backgrounds…(2) articulat[ion of] students' background knowledge…with disciplinary knowledge, and…(3) sufficient school resources to support student learning" (NGSS Release, *Appendix D – "All Standards, All Students"*, 2013, p.6). Vignettes provided by NGSS (Case Study 2, 2013) along with studies by Xu, Coats, & Davidson (2012), Rubba (1989), and Brown (2004) confirm student-learning gains in classrooms that are culturally responsive.

Ms. C is identified in NGSS as a science educator who cares deeply for her students. She maintains high expectations for all of her students and utilizes a variety of instructional approaches to respond to the diverse learning needs of her "65% non-White" student population that is attending an urban school (Case Study 2, 2013, p.1). Ms. C used technology, cooperative learning, and continually "reinforced the idea that scientific discussions become more robust when there are lots of different perspectives" (p.2). Inviting a guest speaker to her class that discussed "global conservation change in Nigeria" (p.2) was so captivating to her students that some shared their experience as immigrants and their lack of knowledge in the area of ecology. The use of student

responses throughout the ecology unit to begin new areas of student exploration is common practice in Ms. C's classroom and, along with the methods mentioned above, provide examples of how Ladson-Billings (1994) tenets of culturally responsive practices can be utilized in science education. Alternate assessments in the form of open-ended questions and research assignments further align to CRP since they provide additional modes of evaluation to expose student knowledge in the content area. In addition to culturally relevant pedagogy, wherein an educator connects students' cultural experiences to science curriculum, Ms. C also used CRP, where educators empower students through the daily structure of classroom activities (Case Study 2, 2013, p.3). Thus, students in Ms. C's class meet NGSS standards through an approach that aligns with CRP (p.9).

Xu, Coats, & Davidson (2012) examine the practices of exemplary African American teachers on the African American students they serve. Viewing science homework as "an important vehicle for involving families and informing them about what their children were learning and for fostering communication between children and their families" (p.13-14), teachers understood the importance of connecting science homework to students' home life (p.16). All African American teachers in the study shared similar approaches to how they ran their classroom as well as homework expectations (Xu, Coats, & Davidson, 2012). The teachers encouraged parents to stop by outside school hours to discuss what the children were learning so that parents could help their children with the homework. In effect, the African American teachers were empowering parents and students by making what was expected of students explicit to students and to families (Delpit, 1988). Students were encouraged to have discussions about what they were learning in science with their families, collaborate with other

students about possible answers, and experience science at home with hands-on homework (Xu, Coats, & Davidson, 2012).

CRP has been shown to act as a bridge between students' home life and school life (Larkin, 2012; Xu, Coats, & Davidson, 2012). Real-world application of science content through a lens of social justice could shorten the bridge by having students address inequities they see in their neighborhood and/or community. A social justice epistemological stance to pedagogy may not be embraced or utilized by teachers in urban settings, but has the potential to help urban youth identify science as "empowering and transformative;" thus, exposing the myriad of information, resources, and talents accessible to students within and among their local community (NGSS Release, *Appendix D – "All Standards, All Students,"* 2013, p.10). Allowing students to hold the power in the science classroom by researching and developing a solution to a community-based problem may address cultural barriers.

Past connection to science content through real-life experiences were suggested through an STS approach utilizing community outreach projects (NRC, 2012). And, the ability to build student, parent, teacher, community, and school partnerships has been identified as an essential element of successful urban teachers (Comer & Maholmes, 2010). In a sample of 65 exemplary science teachers from across the nation, Rubba (1989) analyzed responses to a STS questionnaire. The ideal amount of time identified by participants to be spent on STS issues in class was identified as 15%. Exemplary teachers that were studied chose their STS focus to be centered on globalized issues that were present in the media, but the researchers suggest "community-based issues can be just as interesting…and can provide an opportunity for students to carry out investigations and

take action" (Rubba, 1989, p.699). "The teachers…believed the purpose of integrating STS into secondary science to be an issue awareness as related to concepts and topics of a particular science course" (Rubba, 1989, p.700). The teachers did not choose to have students undertake community action in their neighborhoods. CRP is aligned to STS curriculum. However, CRP focuses more on addressing the needs of marginalized youth, whereas STS focuses more broadly on all students. Figure 1.5 serves as a comparison of practices found within and the two approaches to curriculum.

Practice	**STS**	**CRP**
Acknowledgement of student differences and commonalities	No	Yes
Validate students' cultural identity in classroom practices and instructional materials	No	Yes
"Educate students about the diversity of the world around them"	No	Yes
"Promote equity and mutual respect among students"	No	Yes
"Foster a positive interrelationship among students, their families, the community, and school"	Yes	Yes
"Motivate students to become active participants in their learning"	Yes	Yes
"Encourage students to think critically"	Yes	Yes
"Challenge students to strive for excellence as defined by their potential"	Yes	Yes
"Assist students in becoming socially and politically conscious"	No	Yes
Science for assisting with career choices (Yaeger, 1996, pp.5-6)	Yes	No
Science for preparing for further study (Yaeger, 1996, pp.5-6)	Yes	No

Figure 1.5. Presence of practice: Science Technology Society (STS) and Culturally Responsive Practices (CRP).

While supporting the field of science as a career option and preparing students for future science exploration are not explicit CRP foci, they can be addressed through CRP practices that welcome marginalized youth into the dialogue of science. On the other hand, STS curriculum that addresses the four goals clusters formed through Project

Synthesis (Harm, 1977) aims to provide a science education for all students, but does not focus primarily on students who have been traditionally underserved (Delpit, 1988). Science teacher pre-service and in-service education that thematically integrates the two practices rather than only utilizing one offers potential inclusion of more students into daily science lessons.

Documenting the importance of culturally responsive teaching for student engagement, connection to curricula, and classroom management, Brown (2004) compared thirteen effective urban educators from schools across the nation. Traits that are necessary for teachers instructing in an urban environment were identified, including: a caring attitude, assertiveness and authority, congruent communication processes, and demanding effort (pp.269-273). Findings suggest that classroom management traits of effective urban teachers address *student needs* – one of the tenets of culturally responsive pedagogy (Ladson-Billings, 1994; Brown, 2004). "None of the 13 teachers received any specific training or education in culturally responsive teaching strategies" (Brown, 2004, p.286); rather, time spent in an urban classroom revealed what worked and what did not work with urban students (Brown, 2004).

However, exposure to an urban environment will not, on its own, lead to highly effective urban teachers. In a 2008-2009 Teacher Follow-Up Survey, 97.3% of public school teachers who left their current school remained in a public school either within the same district (51.8%) or in a different district (45.5%) (U.S. Department of Education, 2010, p.11). Furthermore, teachers in a city school identified factors that led them to leave their current school – of the three highest reasons for moving to a different school, 22.7% cited a change in residence as reason for changing their place of employment,

19.8% cited dissatisfaction with the lack of support from administration as reason for changing schools, and 19.6% cited dissatisfaction with administration (SASS, 2010). In comparison, 33.5% of teachers at suburban schools cited change in residence as the reason for their departure (SASS, 2010). When administrative support is missing or lacking in urban schools, urban teachers move elsewhere; perhaps, by providing alternative methods for science teachers to get the support they need – such as through community outreach or structured PD – more educators will be retained at urban schools.

Brown (2004) identified culturally responsive pedagogy as an essential element of pre-service education programs in producing teachers that are able to handle classroom management at urban schools (Brown, 2004); however, CRP is not always implemented with pre-service teachers (Sleeter, 2001). Science teacher PD that integrates CRP has the potential to not only reach urban students in a meaningful way, but also to help teachers navigate an urban student population who may/may not differ from their own educational experience(s) and an urban environment that might not support teacher and/or student needs.

CRP and explicit, reflective practices. Black youth have been found to have trouble identifying with the school community, much greater than White students, because of race issues (Gay, 2000). To surpass an uncomfortable school climate, urban youth must be exposed to pedagogy and practices that encourage connection to real-life experiences as well as collaboration and discussion of various student ideas and viewpoints (Burton & Frazier, 2012). Culturally responsive teaching requires use of “the cultural knowledge, prior experiences, and performance styles of ethnically diverse students to make learning more relevant and effective for them” (Gay, 2000, p.29).

Responding to the needs of “culturally and ethnically diverse learners...[and use of]…student-oriented instructional processes as well as…ethnically and culturally relevant curricula” (Brown, 2004, p.268) is an essential skill to have at an urban school. Explicit discussion of the importance of CRP has to be present in science teacher education programs, and/or be modeled in science teacher PD (Abd-El-Khalick & Akerson, 2004).

The idea of explicit discussion has been shown to be beneficial with students. Khishfe & Abd-El-Khalick (2002) examined the structure of explicit and reflective inquiry-based learning in the classroom. Two groups of sixth-grade students participated in the study – one group was explicitly told of the learning goals for each unit and participated in reflective practices after each inquiry activity; the other group participated in inquiry activities but were neither told of the learning goals nor provided with the time to reflect upon inquiry activities. The latter group (labeled the “implicit” group) was used as a comparison to see if students would reach Nature of Science (NOS) understanding through inquiry activities alone. Analysis of pre-/post-tests showed the implicit group to have no gains in NOS understanding (Khishfe & Abd-El-Khalick, 2002). However, statistically significant gains in the pre-/post-test results of students in the explicit/reflective group were found (Khishfe & Abd-El-Khalick, 2002). Inquiry-based learning “coupled with structured opportunities for students to reflect on what they did in those activities from within a framework of the target [learning goals of] NOS…[showed]… positive [results]” (Khishfe & Abd-El-Khalick, 2002, p.573). The benefits of explicit and reflective practices observed in Khishfe & Abd-El-Khalick’s (2002) study are further supported by the reflective practices embraced with CRP, which

aim to eliminate issues of marginalization found among non-dominant student populations (Delpit, 1988). Therefore, not only do explicit, reflective, inquiry-based lessons lead to significant learning gains in science education, but they have also been suggested to address the ‘science for *all’* requirement (NRC, 2012; NRC, 1996) that is often unmet in science classrooms across the nation.

The reflections on practice of three mathematic and science educators led to revision of curriculum to address the needs of culturally diverse learners (Osisioma, Kiluva-ndunda, & Van Sickle, 2008). Osisioma, Kiluva-ndunda, & Van Sickle (2008) report their own phenomenological narratives about teaching and learning mathematics and science at urban schools. Of the three researchers/teachers, two were educated in Africa and one was educated in rural America – all three taught at urban schools (Osisioma, Kiluva-ndunda, & Van Sickle, 2008). Analysis of the narratives reveals that culturally responsive pedagogy is achieved through “exposure, experience, and reflections” (p.397). Students in the teachers’ classrooms benefited academically by having educators who understood their needs. Students became invested in the curriculum because teachers became invested in them. The researchers suggest that, “to be successful, urban teachers need to teach in ways that are potentially transformative by learning how to identify and connect with the social and cultural resources of their students” (Osisioma, Kiluva-ndunda, & Van Sickle, 2008, p.398). The practice of creating home-school-community partnerships aligns with Ladson-Billings’ tenets of CRP (1994). Training teacher candidates with the skills to be culturally responsive requires embracing the reflective practices documented in Osisioma, Kiluva-ndunda, & Van Sickle’s (2008) study. However, as Sleeter (2001) documents, reflective practices

are only one aspect of developing an effective, urban educator. And, as evidenced by Roehrig & Luft's (2006) study, the road to teacher certification varies – not all science teachers journey the same path.

Challenges of Science Teacher Pre-service Preparation and PD

Science education not only has to be saturated in constructivist methods, but it also has to provide a voice to the traditionally underserved, urban youth. PD that fosters a connection between community culture and school culture has the potential to help students feel invested in the curriculum (Emdin & Lee, 2012). Science teachers that "give [a] voice to diverse ethnic, racial and language communities" (Banks, 2006, p.194) can expose insider perspective[s] known by dominant groups concerning resource attainment and allocation. Opening the door to opportunity for urban youth starts with breaking the barriers that have traditionally maintained the status quo of those who enter science professions (Aikenhead, 1996). Integrating urban cultures and norms into school culture and norms makes resources available that would otherwise have gone unnoticed (NRC, 2012). It is time that science teacher learning focus on making connections to urban youth needs rather than only the content of science.

Challenges in science teacher education programs. Science teacher education programs must better prepare candidates in "instruction in order to teach science to a student population having great diversity in cultures, backgrounds, interest in social learning, language, and reading abilities" (Slough & Rupley, 2010, p.352). The need for science teacher education programs to examine program structure, and include: urban field experiences – both student teaching and community-based projects (Cone, 2009; Sleeter, 2001) as well as discussions and reflections of culturally responsive practices

(Osisioma, Kiluva-ndunda, & Van Sickle, 2008), and inquiry-based learning modeling are clear (Cone, 2009). No longer can science teacher education programs address just the science – they must also address the challenges of teaching at urban schools. When prepared science teachers enter the field there is a higher likelihood that urban schools will retain exemplary science educators.

Calabrese Barton & Berchini (2013) document the feelings of a science intern at an urban school, who feels she is not qualified to teach at the school because she was not raised in an urban environment. The authors provide additional narrative accounts of three science educators who become insiders at urban schools (Calabrese Barton & Berchini, 2013). Whether utilizing active positioning (teacher is a novice and learns about the community through students' shared experiences), critical navigator (teacher plans lessons and discussions that encourage a development of critical consciousness), or symbolic engagement with place (teacher builds relationships with community members), teachers that aim to be insiders to the communities they serve must restructure teaching methods to meet that goal (pp.23-26). Knowing and belonging to the local community, "supports teachers in noticing and leveraging students' non-dominant ways of knowing as integral to the learning process" (p.27). Science educators positioning themselves as active learners of their students, and participants in the school community, effectively engage students in school science and utilize CRP (p.27).

By implementing curriculum that helps students make real-life connections to science, through community outreach projects that expose issues of social injustice, teachers encourage participation in school science from *all* students (NRC, 2012). As stated earlier, student, parent, teacher, community, and school partnerships are an

essential element of successful urban teachers (Comer & Maholmes, 2010). The importance and benefits of school-community partnerships is observed in other fields of practice, too. The health sciences have shown community-based participatory research (CBPR) projects to be successful at causing change within a community's culture (Carney et al., 2012; Spencer, Rosland, & Kieffer, 2011; Ross, 2010).

Positive Youth Development (PYD) and Social Justice Youth Development (SJYD) frameworks guided a study of at-risk students' participation in HOPE (Healthy Options for Prevention and Education), a CBPR Program (Ross, 2010). PYD focuses on urban youth development of "skills, values, attitudes, and competency to be successful adults" (p.684), and SJYD aims to encourage urban youth to "analyze power in social relationships at three levels" – self-awareness, oppressive forces in the community, and global change (p.686). The goal of HOPE was to "eliminate health disparities and to promote community change" (Ross, 2010, p.686-687). Students worked with a professor and graduate student at a local university to develop and carry out HOPE goals in an after-school-program. Policy changes in the local government to decrease tobacco use were made as a direct result of student activity in HOPE. "Young people learned data collection, analysis, and presentation skills" alongside public-speaking, and the importance of networking with "decision makers in the city" (Ross, 2010, p.698). Community-based learning in the context of school science and social justice that is built through a CRP framework has the potential to build the same type of outcomes in urban youth. Professional development that helps science educators include the culture of the community and address issues of injustice therein will support the development of urban youths' connection to school science (Emdin & Lee, 2012). Perhaps by making

connections to urban communities and gaining an understanding of urban space, teachers will begin to change the disconnect that exists between school science practices and home and community practices.

NGSS (NRC, 2012) examines science education for all students – much in the same way that Science for All Americans (SFAA) (AAAS, 1990), the Benchmarks for Scientific Literacy (AAAS, 1993), NSES (NRC, 1996), and No Child Left Behind (NCLB) (U.S. Department of Education, *Title I: Improving the Academic Achievement of the Disadvantaged*) legislation promised scientific understandings and/or literacy for all. Ideas within the NGSS framework highlight STS principles through a "social action approach," that is, science education through engineering practices that address community concerns (Atwater & Suriel, 2010, p.275). Focusing on "social justice…[so that]…students use their knowledge and skills to make decisions about important social issues and take action to help solve problems, including their own" (Atwater & Suriel, 2010, p.275) is an approach to science education that has to be developed and disseminated through sustained PD. Pre-service and in-service educators who, based on demographics of the U.S. teaching population, might not have the background to conceptualize what home life feels like and looks like for urban youth, should be made aware of successful attempts at achieving social justice through the science classroom so that science educators feel encouraged to frame their curriculum around CRP.

For students to develop a multicultural skill set and engage in social justice, they must be exposed to reflective and explicit lesson plans that examine diverse cultures as well as historical and/or current injustice (Banks, 2004). Constructivist classrooms that engage students in examining the field of science from a transformative lens of social

justice offer connections to society that may expose the status quo of power that exists in today's schools, and offer a way for students to establish their own voices within the community of science (Banks, 1995; Delpit, 1988).

To eliminate the academic achievement gap in Science-Technology-Engineering-Mathematic (STEM) fields, Fayon, Goff, & Durzanczyk (2010) suggest teaching practices that encourage students to "evaluate their attitudes and beliefs" (p.9). In their study, surveys were administered to undergraduate ELL (English Language Learners) students enrolled in two sections of an Earth Science course. One section ran with student learning communities (SLC) where students discussed their learning and how the content related to their lives (Fayon, Goff, & Durzanczyk, 2010). The other section did not have SLCs. Students enrolled in the section with SLCs worked with a cohort of other ELL students and experienced curriculum that made connections between their life and content learned in the Earth Science course (Fayon, Goff, & Duranczyk, 2010). Significant student learning outcomes were observed for ELL students working in the SLC environment (Fayon, Goff, & Duranczyk, 2010). ELL students participating in the section containing the SLC also reported a greater connection between the Earth Science content they learned, and experiences that they had within their communities at home, than students in the non-SLC environment (Fayon, Goff, & Duranczyk, 2010).

Teaching science through a multicultural lens requires educators to approach science education from multiple cultural perspectives and provide "opportunities for…students to make decisions and take actions concerning civic duties" (Atwater & Suriel, 2010, p.277). Delpit (1988) suggests allowing students to realize their own place as experts in White culture. Banks (1995) suggests discussion of Eurocentric viewpoints

in class. Using materials provided by family and community stakeholders can help "science teachers not only give…students resources, but [also] draw on the talents and strengths of their students" (Atwater & Suriel, 2010, p.276); thus, transforming students who are marginalized from mainstream school science from caricatures of youth of color to participants in and forces behind societal change (Emdin & Lee, 2012).

The need for culturally responsive practices in teacher education is further supported by Sleeter's (2001) extensive review of the literature on multicultural teaching. White teachers do not bring the same background to the classroom that teachers of color bring (Sleeter, 2001). Most White teachers neither understand the culture of the students they are serving, nor do they address the needs of urban youth (Sleeter, 2001). Teacher certification programs are not identical in program requirements, and may not prepare teachers to facilitate learning in settings with urban students (Sleeter, 2001). Requiring multicultural education courses in science teacher preparation is a necessity; "continuing business as usual in pre-service teacher education will only continue to widen the gap between teachers and children in schools" (Sleeter, 2001, p.96).

Research identifies numerous ways to incorporate multicultural education with science teacher candidates, including: recruitment of teachers of color to teacher education programs, teacher cross-cultural immersion programs, added course work in multicultural education, and multicultural course work with field work in an urban setting (Sleeter, 2001). Programs recruiting teachers of color have been successful at engaging urban students, and immersion programs - requiring teachers to live in the community they are serving – have shown teachers to dramatically shift from traditional classroom instruction to "engaging students with subject matter, using culturally relevant

knowledge" (p.97). However, minority recruitment into pre-service education programs will not solve the problem of White, middle-class teachers entering urban districts, and immersion experiences will be difficult to institutionalize with pre-service education programs (Sleeter, 2001).

Multicultural education courses have been shown to "raise students[-teachers'] awareness about race, culture, and discrimination" (Sleeter, 2001, p.98), but awareness and changes to practice are on two sides of the continuum for reaching urban youth. In fact, some multicultural course work was found to be counterproductive to teacher candidates because the classes taught stereotypes and did little to change views on culturally responsive pedagogy (Sleeter, 2001). Something must be done in science teacher education for White teachers, who are unfamiliar with the community they serve, to understand the barriers present for their students. Science teacher PD programs provide a second outlet for training teachers in culturally responsive practices.

Challenges in science teacher professional development programs. Spillane et al. (2001) identify challenges that are faced by science teacher PD in urban settings, including the development of (1) physical capital, (2) human capital, and (3) social capital (p.920). Adams School utilized all three forms of capital in its transformation from a school with an isolated teacher population in an economically disadvantaged area of Chicago, IL, with little to no science instruction, to a cooperative, trusting school environment with a growing science fair, connections to local Universities, and administrative support for science education (Spillane et al., 2001). Adams School demonstrates that when an entire school is engaged in PD and the physical, human, and

social capital needs are met, teacher and student learning gains are made in science education (Spillane et al., 2001).

Physical capital: resources. Tate (2001) relates the lack of motivation in engaging students in science education to a school's focus on state testing (p.1020). Spillane et al. (2001) identify urban district administrators and teachers to have a philosophy that children living in poverty should be educated with basic skills necessary to graduate, and they do not value science as a subject area (p.921). As a result, science education does not receive adequate PD, support, or budget allowances when compared to other subject areas – namely, English and mathematics (Spillane et al., 2001). NGSS does not have a mandated test for school accountably that will support its implementation; whether the lack of NGSS testing will be helpful or a hindrance to the science education students participate in remains unclear.

The development of epistemological understanding observed by Dr. Hennessey's students will be absent in schools that fail to recognize the importance of, and the educational growth found in, constructivist science education (Smith, Maclin, Houghton et al., 2000). Furthermore, Tate's (2001) argument that science education is a civil right will not be realized unless steps are taken to make sure exemplary science education programs are implemented in urban schools – elementary through high school levels. PD that helps teachers find resources to support science education outside of the school budget may help educators navigate unforeseen consequences of the new standards, namely CCSS and NGSS, under NCLB revision and RTTT. CRP is one approach that science teacher education programs should model to better prepare teachers for the challenges they will face in urban settings and it opens the doors to resources through

community outreach. CRP might also be one method that PD designers integrate into programs to help educators who are already in urban settings and are finding navigating an unfamiliar urban school environment to be a challenge (Cone, 2009).

Teaching loads. Given the lack of resources available to urban schools, teacher quality as well as teacher quantity is a problem facing urban youth (Banks, 1995). Teaching responsibilities that involve large class sizes and multiple class preparations prevent time spent revising curriculum. Further hiring of new and uncertified teachers that have not been trained to address the cultural, emotional, and ethnic needs of their diverse student body, adds to the challenges of successful PD in urban settings. “Student-oriented instructional processes…[and]…choosing and delivering ethnically and culturally relevant curricula” (Brown, 2004, p.268) must be achieved by urban educators. In the sciences, culturally responsive teaching is especially important because it is here that students experience ideologies present in the subculture of science which further perpetuate a White, male scientist stereotype (Aikerman, 1996). PD that provides materials for teachers to use in the classroom, and allocates time to revise science curriculum using culturally responsive teaching will benefit urban students.

Human capital: Teacher demographics. According to the National Center for Education Statistics, 3.3 million full-time, public school teachers are at work in the United States – 83% White and female (U.S. Department of Education, 2010). The U.S. teacher demographic is in direct contrast with the youth population seen in urban schools – namely, poor, students of color (Larkin, 2012). The cultural divide in schools serving urban youth is a barrier and a challenge in itself that has to be acknowledged and addressed. PD programs using a framework of culturally responsive practices – where

student culture is at the center of lesson planning – has shown statistically significant gains with student learning outcomes (Johnson & Fargo, 2009). Science teacher education programs and other forms of PD must address the disparities present in urban settings, including a need for cultural connection(s) to the curriculum.

Unfortunately, many science PD programs do not focus on urban issues; rather, they focus on science concepts and technology (i.e. photosynthesis, cellular respiration, molecular genetics, iPads, probeware) (Johnson & Fargo, 2009). Will furthering the understanding of science concepts and technology alone address the gap that remains between urban and suburban students? Does the structure and objectives of science teacher PD need to address the disparities found in urban districts through the modeling of lessons that encourages all students to feel empowered in the classroom (Ladson-Billings, 1994)?

PD that is implemented has to be supported by the school. Inquiry education, for example, is known to be "valuable for many underserved and underrepresented populations" (Haury, 1993, p.3), but it is not often used in such classrooms (Davis & Martin, 2008). African-American students in particular have been identified as being continually exposed to such practices as 'teaching to the test' as a "dominant instructional approach" (Davis & Martin, 2008, p.11), emphasizing "remediation, skills-based instruction…decreased use of rich curriculum materials, narrow teacher flexibility in instructional design and decision making, and the threat of sanctions for not meeting externally-generated performance standards" (p.11). Minority students often experience low-level expectations and remedial work while middle-class White students attend

schools that “attract teachers who stay longer [and] access better resourcing” (Pratt-Adams, Maguire & Burn, 2010, p.35).

Spillane et al. (2001) examine seven high-poverty schools in Chicago, each with varied student demographics, and found elementary schools to have limited administrative support and budget allowances for science education when compared to both language-arts and mathematics education. A loss of focus on what is important for the development of the child is often found in urban-settings. For example, minimal to no support for teacher PD led to the elimination of a science education in elementary classrooms because teachers had little to no background in science, and the subject was not being assessed.

Attrition. According to Tate (2001), “in many large urban cities the rate of retiring and re-locating certified mathematics and science teachers is growing at a pace that far exceeds the production of graduates in SMET [Science, Math, Engineering, and Technology] education” (p.1023). SMET graduates have many options available to them, including teaching in suburbs or working in industry - both of which provide “economic advantage over urban schools…there is a price for quality” (p.1023). However, Adams School (Spillane et al., 2001) shows that administrative support and a collaborative/ cooperative teaching environment can lead to significant changes in the climate of the school – including retaining teachers. With many urban school districts lacking the monetary incentives to attract highly qualified educators, PD that addresses restructuring the school climate may benefit urban schools. Culturally responsive teaching aims to bridge the school’s local community with classroom lessons so that students, teachers, and the school can be made aware of the richness within and among the surrounding area.

When more students and teachers are invested in the local community, positive influences in school climate may be felt throughout the building.

Science is constantly changing, and science education requires teachers to be provided with continued professional development to keep up with advancements (Tate, 2001). The question remains whether or not there is a problem with PD that is solely focused on science advancement and does not allocate time to issues found in urban settings. A lack of administrative and school support, the juxtaposition of teacher demographics and the students they are serving, and teacher attrition remain key challenges that science PD programs should consider when designing an event. Teacher PD that addresses issues commonly found in urban settings while simultaneously exploring scientific advancements supports urban teachers and may have profound effects on urban students. Teachers trained in CRP may find the pedagogical approach effective when looking for methods that address the needs of urban students.

Social capital: School culture & climate. Even if "policies are established…that address low wages, insecure work and the lack of good public housing" in urban areas, White culture and White curriculum remain dominant in schools (Pratt-Adams, Maguire & Burns, 2010, p.128). The subculture of science expects students to "acquire science's norms, values, beliefs, expectations, and conventional actions," but does not consider the wealth of insight students bring to the classroom through their own personal experiences (Aikenhead, 1996, p.10). PD that models CRP may change the minds of urban science educators concerning how to address and structure the learning environment for urban students. For example, Emdin & Lee (2012) call for an understanding of hip-hop culture among teachers in urban settings. Educators and policy makers who see the cultural

significance of hip-hop and tie that culture into the educational climate may open doors to science education for urban youth (Emdin & Lee, 2012). The "normative descriptions of discipline-specific subject matter in schools…tend[s] to restrict the intellectual and expressive opportunities youth have in school and thereby reproduce the privilege…of whiteness" (Bang et al., 2012, p.303). As a result, "many minority students have never had an opportunity to see themselves as other than a caricature of youth of color" (Emdin & Lee, 2012, p.10-11). Traditionally associated with learning and behavior problems, urban youth need to see their fit in the science classroom (Emdin & Lee, 2012). PD that helps science educators embrace the culture(s) found in urban settings and includes the culture of the community they are serving with classroom lessons will help urban youth feel connected to science (Emdin & Lee, 2012). Therefore, along with "subject-matter knowledge, pedagogical knowledge, years of experience, behaviors and practices, knowledge of learning, and/or certification status" (Tate, 2001, p.1023), quality teachers must add culturally responsive teaching to their list of essential traits. Empowering marginalized youth by recognizing and embracing different values, beliefs, and ways of knowing, and structuring lessons to bridge community and school stakeholders may help the typical, White urban educator understand the needs of urban students.

Community culture. Successful understanding of community culture lends itself to "useful information or resources with which to enhance a school's instructional program, resources that would not have been accessible to the school absent these relationships" (Spillane, 2001, p.921). For example, urban youth see themselves succeed in the political arena because of President Obama's explicit connections to his culture throughout his terms in office (Emdin & Lee, 2012). The President's choice to 'fist-

bump' his wife and 'brush off his shoulder' at public events shows his roots in hip-hop culture, and helps urban youth feel comfortable exploring the field of politics (Emdin & Lee, 2012). Restructuring science curriculum to align with cultural norms of the community and/or incorporating community partnerships into lesson plans may lead more urban youth to show interest in the sciences.

PD that addresses how CRP can be worked into science curriculum requires examples of successful incorporation for pre- and in-service educators. The realization that multiple stakeholders – community leaders, school leaders, teachers, students, and parents – share a role in tying science curriculum to community culture may be daunting, especially for an outsider to the community. However, PD that encourages teachers to make connections with students' home-life by providing networks to community stakeholders may alter the "disconnect between school science practices and home and community practices of non-dominant student groups" and aligns with CRP (NGSS Release, *Appendix D – "All Standards, All Students"*, 2013, p.8).

Johnson & Fargo's (2009) longitudinal study of whole school PD in science education shows "an increase in [student] scores across the 2 years [for the experimental schools] …compared to a loss [in scores] for the control schools" when teachers are involved in the design of their own PD (Johnson & Fargo, 2009, p.19). Teachers create a community of collaboration within the school, make home visits, learn Spanish, and construct lesson plans to make the science they teach meaningful to the students they serve (Johnson & Fargo, 2009). Culturally responsive lessons are aligned with urban minority students' needs. The investigation supports sustained PD experiences rather than "short-term opportunities in order for real change to take place that impacts student

achievement" (p.25). By "attempt[ing] to challenge and change the educational provision, its contents and pedagogy" (Pratt-Adams, Maguire & Burn, 2010, p.93) through the incorporation of cultural connections, teachers begin to address the barriers present within the U.S educational system and students benefit.

Building cooperation and trust within a school and/or district can lend itself to advancements in social capital as it builds school morale. For instance, the increased presence of science curriculum at Adams School is a direct response to administration's choice to encourage a collaborative and trusting staff environment (Spillane, 2001). Cooperation among staff members formed networks of teachers that encouraged information sharing and leadership positions to be recognized and appointed. Eventually, school-University partnerships formed, extending the school network and bringing even more resources to the school. To overcome the obstacles of an unsupportive administration and school environment, PD must aim to foster collaborative teacher environments that embrace culturally responsive teaching practices.

Figure 1.6 summarizes of the forms of capital challenging science teacher PD and also identifies the effects of deficient forms of said capital on schools (Spillane, 2001).

	Physical Capital	Human Capital	Social Capital
Description	• Money • Resources (i.e. lab equipment, textbooks, technology)	• Knowledge of a culture • Knowledge of how to teach to reach all students	• Home/school partnerships • Community connections • Relationships with the community
Effect(s) on Schools when Not Present and/or Lacking	• Budget cuts • Loss of teachers • Closure of school • State testing becomes a focus of curriculum • Teachers do not receive adequate PD • Increase in student:teacher • Decrease in teacher quality	• Cultural disconnect between teacher(s) and students • Cultural disconnect between school culture and student culture • Increase in teacher attrition • Increase in student:teacher • Decrease in teacher quality • Low test scores • Budget cuts • Closure of school	• Decrease in physical capital • Disconnect between school staff and student body

Figure 1.6. Description of the forms of capital and the effects on schools when the form of capital is not present and/or lacking in a school.

Measuring Change in Culturally Responsive Teaching Practices

Teacher self-efficacy “is defined as a teacher’s belief in his or her ability to influence how well students learn, even those who are considered to be difficult or unmotivated” (Cone, 2009, p.367). Academic tracking continues to place minority students who have not received a quality education in low-level courses, which are often instructed by teachers that have low self-efficacy (Cone, 2009). Believing that they cannot reach students with diverse backgrounds, many educators have low expectations for students of color, and choose to use direct instruction (Cone, 2009). In direct contrast with what has been shown to work with urban youth, direct instruction and low expectations exacerbate the problems stereotypical of urban classrooms, namely disruptive learning environments. Kids are placed into inferior learning environments rather than into dynamic learning opportunities. Science teacher PD programs must address teacher self-efficacy to break the yearly cycle that many urban youth experience when entering classrooms that are led by teachers who do not believe in their students’ abilities.

Cone’s (2009) study of pre-service elementary science teachers’ self-efficacy before and after participation in a science methods course that incorporated community-based science learning (CBSL) experiences with explicit discussions of diversity indicates that CBSL and diversity discussion alone do not show significant change in teacher self-efficacy. However, when employed together CBSL and diversity discussions show positive gains in elementary teacher’s self-efficacy for instructing science (Cone, 2009). CBSL and diversity discussions mirror the Conceptual Change Model (CCM)

framework put forward by Larkin (2012) and may offer strategies for science teacher PD programs' incorporation of culturally responsive practices.

CCM encourages measurement of students' learning outcomes through constructivist teaching, and is suggested as a method for measurement for teachers' learning outcomes for CRP (Larkin, 2012). It is unexpected that a teacher will change his/her beliefs about teaching after a methods course in multicultural education during their pre-service education, much the same way that it is unlikely that a student will fully grasp the processes of cellular respiration, photosynthesis, or how to use an iPad with students at first attempt. Rather, continued PD that thematically integrates culturally responsive teaching in science education with scientific practices will help science educators move multicultural education into the curriculum (Banks, 1995). Larkin (2012) identifies two examples of science teachers in which conceptual change took place after working with culturally diverse students. "To be effective…teaching for conceptual change…requires careful attention to the existing ideas of the learner…instruction based on these ideas, and adequate time for students' explicit consideration of competing ideas" (p.28). Figure 1.7 shares these elements.

Element	Explanation
Reflection	Reflection of practice; prior conceptions of school, society, students, and self are identified
Explicit Discussion	Alternate ideas are presented for consideration; Discussion of one's ideas about school, society, students and self

Figure 1.7. The two elements of the Conceptual Change Model (CCM) (Larkin, 2012, pp.27-28).

Aligned with Ladson-Billings (1994) tenets of culturally responsive practices, Larkin's (2012) CCM is based on the reflective practices of teachers' ideas about cultural diversity in the classroom, and it may show to be an effective way to measure science

teachers' effectiveness with *all* students. PD programs that incorporate CCM may inform other teacher PD whether or not reflective practice along with explicit discussions change teacher understanding of CRP.

> If the prior conceptions that prospective teachers hold about students, schools, learning, society, and, perhaps most important, themselves continue to enjoy high status within their conceptual ecologies, it seems likely that these concepts will be quite resistant to change. (p.26)

The CCM offers a step beyond cognitive dissonance; it suggests that alternative ideas concerning student diversity should be presented to pre-service teachers, and, by extension, in-service teachers, so there is an opportunity for existing conceptions to be replaced. Existing ideas of the learner are central to CCM – instruction is based on it and time is given to students to consider competing ideas (p.28). Perhaps, science teacher PD can use the CCM to encourage culturally responsive practices in the classroom. By integrating reflection of teachers' prior ideas concerning school, society, students, and self, through both social and cultural barriers, and offering alternative ideas during group discussion, CRP can be utilized by in-service educators.

Abd-El-Khalick & Akerson (2004) applied CCM to their investigation of elementary pre-service teachers' notions of the Nature of Science (NOS). Teachers shared existing beliefs about NOS, reflected on their beliefs through various readings and activities, and reflective papers (Abd-El-Khalick & Akerson, 2004). Results showed pre-service elementary teachers to have significant change in understanding of NOS. The "strategy…satisfied conditions for learning as conceptual change [and] was notably effective in helping participants develop informed views of the target NOS aspects"

(p.797). Teachers are situated in environments where they are direct participants of constructivism – figuring out what works best for students as they develop and refine curriculum through years of experience, reflection, and revision. CCM can measure science teachers' change in knowledge of CRP after reflecting upon CRP and having explicit discussions of diversity with peers in PD programs (Cone, 2009). "The conceptual change model has important implications for the goals of teacher education for diversity" (Larkin, 2012, p.26). Incorporation of the CCM framework into science teacher PD experiences may have a positive effect on the integration of CRP at urban schools.

Science Education: A Civil Right

Tate (2001) identifies science education as a civil right and distinguishes a historical shift from macro-level arguments, which challenge school segregation, to micro-level arguments, which aim to "create an intellectual space for all students within every school across demanding content domains" (p.1017). He not only identifies the need to create equal spaces, but also to create quality education for all. Programmed into the minds of White educators is that ideas contrary to traditional practices are inferior, and that researched-based methods constitute quality education (Delpit, 1988). White teachers, White parents, and White students often cast an environmentally poor home life as the agent responsible for urban students' underachievement on standardized tests (Greene, 2000) – "a tendency, laid down over time, to 'blame' individual children, their parents, their schools and their teachers for any 'failure' in educational attainment" (Pratt-Adams, Maguire & Burn, 2010, p.94). The true failure lies in a misunderstanding of the wealth of resources found within and among urban schools by urban students and

their families. Misunderstood is that the cultural experience urban students embrace at home may be different from those embraced by the school. Families of urban students “operate within perfectly wonderful and viable cultures but not cultures that carry the codes of rules of power” (Delpit, 1988, p.283). Students who do not bring White, middle-class experiences with them should not be discriminated against through misguided instructional practices (Atwater, 1995). Throwing money at programs that aim to re-create a White childhood fails to acknowledge the vast wealth of knowledge, perspectives, and insights that urban communities hold concerning what is best for their children.

Explicit in NSES (NRC, 1996) is science understanding for *all* students (Collins, 1997). Science teachers are to “recognize and respond to student diversity when planning, guiding, and facilitating student learning” (p.304). The “culture of power” found in school science prevents minority populations from participating (Calabrese Barton & Yang, 2000; Delpit, 1988). Student understanding of science “implies facility in inquiry and a breadth and depth of knowledge about facts, concepts, laws, and theories that describe, explain, and predict natural phenomena” (Collins, 1997, p.304). However, White groups and White viewpoints have structured the knowledge and ways of knowing that are deemed acceptable by U.S. schools (Aikenhead, 1996).

> Consequently, there is a long history of the culture of power dominating school science through such things as how… science gets defined, how science is taught and practiced, and how science is treated in relation to the rest of the world. (p.875)

Reflection of knowledge – what is known, how knowledge is known, and the value of the knowledge – should be practiced alongside inquiry if one aims to create a climate that encourages participation by *all* (Collins, 1997, p.304).

A case study by Calabrese Barton & Yang (2000) identifies a young man of Puerto Rican descent, Miguel, whose goal is to help his daughter navigate the culture of power that dominates schools in the United States. Rather than recognize the failure of U.S. policies to provide him with a culturally responsive curriculum that embraced his talents in science, Miguel identifies his own culture as the problem for his failure at school: “it was *necessary* to learn from the dominant culture in order to succeed both in school and in science” (Calabrese Barton & Yang, 2000, p.881). Delpit (1988) identifies the culture of power as a realization that White, middle-class persons have control over policies, beliefs, ways of acting and dressing. When students do not recognize the need to embrace the culture of power early their education, opportunities for advancement are limited (Calabrese Barton & Yang, 2000). Miguel’s experience, in which his own science knowledge was not realized or valued by teachers, suggests: “the culture of power…plays a large role in who formally succeeds in American culture and who stays in the margins” (p.884). Losing his job and living with his wife and daughter in a homeless shelter, Miguel’s story suggests that, “success is defined through how close one can come to emulating the established dominant culture” (p.885). What then, can be done so that Miguel’s story does not occur to countless other “underprivileged, ethnic minorities” (p.884) attending schools in the U.S.? Calabrese Barton & Yang (2000) offer a suggestion:

> If all students are to be allowed to become full members of the culture of power in science and science education – and to be allowed to help shape that culture – then we must seriously consider not only how we teach science, but also the science that we teach and its relationship to students. (p.876).

The answer of how to address the culture of power begins with science teacher education programs providing teacher candidates with preparation, knowledge, and experience in teaching urban-youth and continues with in-service teacher PD that addresses the needs and navigation of an urban student culture. For millions of educators across the Nation, in-service PD that models effective practices that prepare teachers for student diversity may begin to address the achievement gap present in today's urban schools.

A child's upbringing should not bar him/her from being accepted into the school community (Delpit, 1988). White policies, White standards, and White assessments have ostracized non-White children (Delpit, 1988). Science educators must learn how to engage students from unfamiliar backgrounds and utilize the wealth of resources found within the local community, thereby ensuring a quality education for all. School curriculum that offers a one-dimensional view of the world is a disservice to both urban and non-urban students (Delpit, 1988). Teachers must recognize the power they hold, and look for explicit ways to "provide for students who do not already possess…the additional codes of power" reality of that power, and an appreciation for students' own cultural values (p.293).

While multicultural education was developed in response to minority groups' feelings of marginalization, social justice aims to confront disparities present among

marginalized groups (Banks, 2004). Banks (2004) identifies the need for standardized tests to assess more than just core subject matter of English and mathematics. Students "should have the knowledge, skills, and commitment needed to change the world to make it more just and democratic" (p.291). In-service science teachers need to have CRP in their box of tools to effectively reach *all* students and not just the academically elite (Aikenhead, 2005).

Summary of literature review. Research has identified characteristics of science teacher PD that benefits all students (Tate, 2001). The review explored the history of science education standards on classroom practice, constructivist and culturally responsive practices in the urban classroom, and science teacher professional development. How the results of this study will be analyzed is now explained.

Chapter 2: Theoretical Framework

Wilson & Berne (1999) examine the evolution of teacher PD. Preparation for the teaching profession includes the use of field experience(s), method and foundation courses in education, and subject matter courses in specific disciplines; however, even these aspects of pre-service teacher education varies (Roehrig & Luft, 2006; Wilson & Berne, 1999). Furthermore, changing curriculum and implementing state testing have not shown to change teaching practices (Wilson & Berne, 1999). In-service educators participate in a myriad of PD, including: partial-day and/or full-day workshops delivered by school districts, learning opportunities, and professional organizations – a “patchwork of opportunities” (p.174). Such forms of teacher PD are ineffective for teacher and for student learning (Wilson & Berne, 1999). The elements of effective PD are identified after analysis of various programs and include: “teacher learning…not bound and delivered but…activated” (p.194), “engag[ing] [teachers] as learners in the area that their students will learn in but at a level that is more suitable to their own learning” (p.194), and “privileging…teachers’ interaction with one another” (p.195).

Additional findings include the need for “substantial commitment to examining teacher talk in interview and group conversations and teachers’ classroom behaviors” in order to document teacher knowledge resulting from PD (p.195). While teachers do not expect to have their own “knowledge held suspect or their previous practices questioned… professional development designed to help teachers acquire new professional knowledge, especially subject matter knowledge…involve[s] just that” (p.200). Wilson & Berne (1999) offer four observations of teacher PD, including:

(1) researchers tell thoughtful and personal stories of their struggles to create…communities of learners and of the importance of focusing teachers' attention students and their ideas, on subject matter worth learning;

(2) [a] need for subject-specific investigations of teacher learning…science teachers engage…in experiments and scientific inquiries;

(3) the "what" of teacher learning being identified, conceptualized, and assessed. Models of knowledge are built to measure teachers' acquired knowledge;

(4) link[ing] studies of teacher learning to teaching behavior and to student achievement;

(5) systematic theorizing about the mechanisms by which teachers learn. (pp.202-204)

Research in the field of teacher PD has not shown to successfully intertwine "teacher learning, professional development, teacher knowledge, and student learning" into one cohesive study (p.204). The need for research that studies the integration on all aspects of teacher PD is clear.

Specifically investigating science teacher professional development, Supovitz & Turner (2000) found "the most powerful individual influences on both teaching practices and investigative culture were teachers' content preparation and attitudes towards reform" (p.974). Six research-supported ideas concerning science teacher PD include:

(1) immersing teachers in inquiry, questioning, and experimentation,

(2) lengthening the time teachers spend in PD,

(3) engaging teachers in experiences that are grounded in teachers' experience with students,

(4) deepening teacher content knowledge

(5) connecting PD to state standards for student performance, and

(6) connecting PD to school change. (p.964-965)

Science teacher PD that included sustained and intensive activities had the most significant impact on "teaching practices and classroom culture" along with content preparation, which showed to be the greatest contributor towards change (pp.975-976). Noteworthy, teachers from poorer schools showed the least change at reform efforts in the science classroom (pp.976).

Culturally Responsive Teaching Practices

Ladson-Billings' (1994) tenets of culturally responsive practices were identified in the literature review, and include learner-centered approaches that empower students to investigate issues related to their community (Basu & Calabrese Barton, 2006). Culturally responsive practices that are suggested include: helping marginalized youth become "intellectual leaders in the classroom" (Ladson-Billings, 1994, pp.117-118), creating a classroom that encourages a community of learners, and relating content to real-life experiences – particularly those events central to section(s) of the student body who are isolated from dominant, White school culture and policy. Furthermore, formative assessments that include a myriad of methods outside of traditional paper and pencil tests that engage students in discussion(s) and action(s) which expose the status quo and elicit change in the local community through outreach projects give power to traditionally

marginalized urban youth who attend schools built upon and framed around White culture (pp.117-118). Teachers must be aware of their own personal biases as well as their own power to draw out of a student body the need for change and/or improvements in the school's local community and/or locating resources provided by the school's local community (pp.117-118). By encouraging all students to be "intellectual leaders in the classroom," students' real-life experiences become a part of the "official curriculum" (pp.117-118). PD needs to focus not only on science content but also on methods that marry science content to serve underserved – urban youth.

Culturally responsive practices are not often integrated with pre-service teacher education coursework, but teachers – particularly urban teachers – must be aware of ways to reach urban students (Roehrig & Luft, 2006; Wilson & Berne, 1999). Activities that teachers can incorporate into their lesson plans as well as explanations of how the activities are culturally responsive are found in Figure 1.4 in the literature review. Teachers must be exposed to how culturally responsive practices can be incorporated into the science content they are learning during PD. PD focused exclusively on science content continues to ignore underserved urban youth who have traditionally been alienated by White school policies and White school culture (Delpit, 1988). PD alignment to culturally responsive practices may lead to positive teacher and student learning outcomes for all students. If the goal of PD is to have gains in teacher learning and for those gains to be transfer into student learning, PD programs must acknowledge the needs of all students, not just those comfortable with the traditional practices (Wilson & Berne, 1999). And yet, science teachers also need a depth of content knowledge.

Content Knowledge (CK)

While subject-matter knowledge – content knowledge – is gauged by tests prior to achieving teacher certification, it is not the only indicator of quality teaching. Policy makers proposed seven categories for teacher evaluation, including:

(1) organization in preparing and presenting instructional plans,

(2) evaluation,

(3) recognition of individual differences,

(4) cultural awareness,

(5) understanding youth,

(6) management, and

(7) educational policies and procedures. (Schulman, 1986, p.5)

Interestingly, content knowledge was, initially, left out how policy makers aimed to assess teacher quality, in spite of its importance in passing content-based teacher certification tests. In fact, content mastery tests are only required at initial onset of teacher certification, even though science knowledge itself continually changes. Instead, the focus on teacher evaluation surrounds teachers' use of class time, instructional methods, and classroom management. Minimal attention is given to teachers' content knowledge and/or how teachers apply content knowledge to curriculum. Content knowledge is often supported in pre-service teacher education through courses taken in specific disciplines and is reinforced in science methods course work (Sleeter, 2001). "Today, pre-service teachers must take the Praxis II exam, which assesses their content knowledge, but after certification, there is no other assessment of a teacher's content knowledge, even as research expands the fields drastically each decade" (B. Bales, personal communication, January 31, 2014). Furthermore, the role of Pedagogical

Content Knowledge (PCK) in teaching and in learning has been left out of the evaluative process, but needs to be explored (Schulman, 1986; van Driel, Verloop, & de Vos, 1999).

Pedagogical Content Knowledge (PCK)

While the importance of merging a teacher's knowledge of content with a teachers' knowledge of how to teach that content is of secondary importance in teacher evaluations, it is one of the more important aspects of teacher quality (Schulman, 1986). Schulman (1986) identifies the need to evaluate teachers based on "the content of the lessons taught, the questions asked, and the explanations offered" (p.8). PCK concerns the teacher's ability to transform the content to aid in student understanding (van Driel, Verloop, & de Vos, 1999; Schulman, 1986). As much attention should be paid to "the content aspects of teaching as…to the elements of teaching process" (Schulman, 1986, p.8). Schulman (1986) further describes three types of knowledge teachers are expected to obtain, including: content knowledge, pedagogical content knowledge (PCK), and curricular knowledge. Of the three types, content knowledge is routinely emphasized in teacher pre-service education, but PCK and curricular knowledge have, historically, been left out (See Figure 2.1) (Schulman, 1986). PD that addresses PCK and curricular knowledge is essential to achieve high quality teachers and high quality classroom lessons for all students (Schulman, 1986).

Type of Teacher Knowledge	Description
Content Knowledge	• amount of knowledge (understanding of what and why something is known) • organization of knowledge
Pedagogical Content Knowledge	• knowledge of subject matter for teaching • “the ways of representing and formulating the subject that make it comprehensible to others” (p.9) • knowledge of conceptions, preconceptions, and misconceptions about the subject area • strategies to address various aspects of subject area conceptions, preconceptions, and misconceptions
Curricular Knowledge	• knowledge of programs and instructional materials that can be used for particular subject area (i.e. “alternative texts, software, programs, visual materials, single-concept films, laboratory demonstrations,” etc.) (p.10)

Figure 2.1. Schulman's types of teacher knoweldge.

Conceptual Change Model (CCM)

Larkin’s (2012) Conceptual Change Model has shown to be effective in measuring teachers’ knowledge of the Nature of Science (NOS) (Abd-El-Khalick & Akerson, 2004). Through readings, reflection – including explicit discussion of culturally responsive practices with peers – and writing, pre-service elementary teachers showed significant gains in NOS understanding (Abd-El-Khalick & Akerson, 2004). CCM involves using the “thinking of individuals as the unit of analysis.” (Larkin, 2012, p.13). “Analyz[ing] the text of a written narrative has the advantage of using [a] built-in structure created by the author that clearly points to significant events and issues” (p.24). In other words, a teacher’s written account of his/her conceptions about urban students

provides a “conceptual ecology,” or personal biases, that can be analyzed (p.28). When teachers fail to recognize their own biases towards curriculum and towards the students they teach, change in a teacher’s “conceptual ecology” may never change to support the student body being served (p.26).

Adding further support to CCM as a tool to incorporate culturally responsive practices in the classroom, Ladson-Billings (1994) identifies a teacher’s need to recognize his/her own biases as one of the tenets of culturally responsive practices. However, cognitive dissonance, or one’s dissatisfaction with his/her conceptions of students, school, society, etc. is not enough to cause change of his/her conception(s) unless an “alternate conception is available” (Larkin, 2012, p.26). Science teacher PD that presents alternative ideas and/or conceptions to a teachers’ “conceptual ecology” offers the potential for change in teacher understanding of students and/or culture that is different from their own (p.26). Recognition of one’s “conceptual ecology” through personal narrative and embracement of alternate ideas along with explicit dialogue with peers offers the possibility for teachers to “undergo conceptual change more readily” (p.28). Larkin (2012) cautions teacher educators against basing instruction on “a ‘right answers’ approach” to culturally relevant practices (p.28). “To be effective…[CCM]…requires careful attention to the existing ideas of the learner…instruction based on these ideas, and adequate time for…explicit consideration of competing ideas” (p.28). Whether or not PD programs incorporate CCM into their program design may provide insight into whether or not practices employed are effective for urban students.

Content Knowledge & Pedagogical Content Knowledge, along with Culturally Responsive Teaching and CCM

Interestingly, Schulman (1986), Wilson & Berne (1999), and Supovitz & Turner (2000) do not include the importance of community connections – one of the tenets of culturally responsive practices – in their theories on teacher professional development. In fact, Ladson-Billings' (1994) identification of culturally responsive pedagogy is missing from much of the research on science teacher PD. Whether or not Ladson-Billings' tenets of CRP are integrated into science teacher PD will be explored in this study. Wilson & Berne's (1999) and Supovitz & Turner's (2000) theories on teacher professional development, and Schulman's (1986) recommendations for PCK development will also be explored in this study.

The CCM utilizes explicit and reflective practices as a method of measurement for teacher learning outcomes, it also exposes teacher biases found within the field of science (Aikenhead, 1996) as teachers reflect and discuss personal beliefs when developing their "conceptual ecology" (Larkin, 2012, p.28). CRP encourages the use of explicit and reflective practices for teachers to examine their own biases on student populations who may differ from their own. CRP also promotes gains in student populations who have been traditionally underserved by having teachers become aware of and utilizing cultural connections previously unrealized. PCK bridges teacher CK with an understanding of how to facilitate learning to all students, not solely through traditional practices of direct instruction and memorization of facts; rather, students explore content and make connections on their own through a journey that the teacher constructs for the student. Finally, CK – the material assessed on certification tests like Praxis II exams – is essential for instruction, but can also contain scientific biases that

must be reigned-in by the teacher. Thus, the theoretical framework for this study examines four elements of effective teacher practice – reflection, CRP, PCK, and CK.

Measuring teacher-learning outcome(s) has been identified as a consistent problem in educational research concerning teacher PD. “Conceptual change is considered to take place if the status of an idea changes, such as in the case of the status of a new conception becoming greater than a previous one” (Larkin, 2012, p.10). Whether or not explicit, reflective practice(s) are found within PD, and whether or not CRP, PCK, and CK are observed and effect teacher learning outcome(s) will be examined in this study.

Summary of Theoretical Framework

Science teacher PD, PCK, culturally responsive practices, and the CCM have been explored in this section (Wilson & Berne, 1999; Supovitz & Turner, 2000; Schulman, 1986; Ladson-Billings, 1994). SUN, SEPA, and CLA PD programs will be analyzed for their alignment to the theories. Figure 2.2 illustrates connections between the theories and illustrates the confluence of the theories explored in this study. The methodology used to examine how science teacher summer professional development programs affect teacher learning outcome(s) and any subsequent translation into their classroom practice(s) is shared in chapter 3.

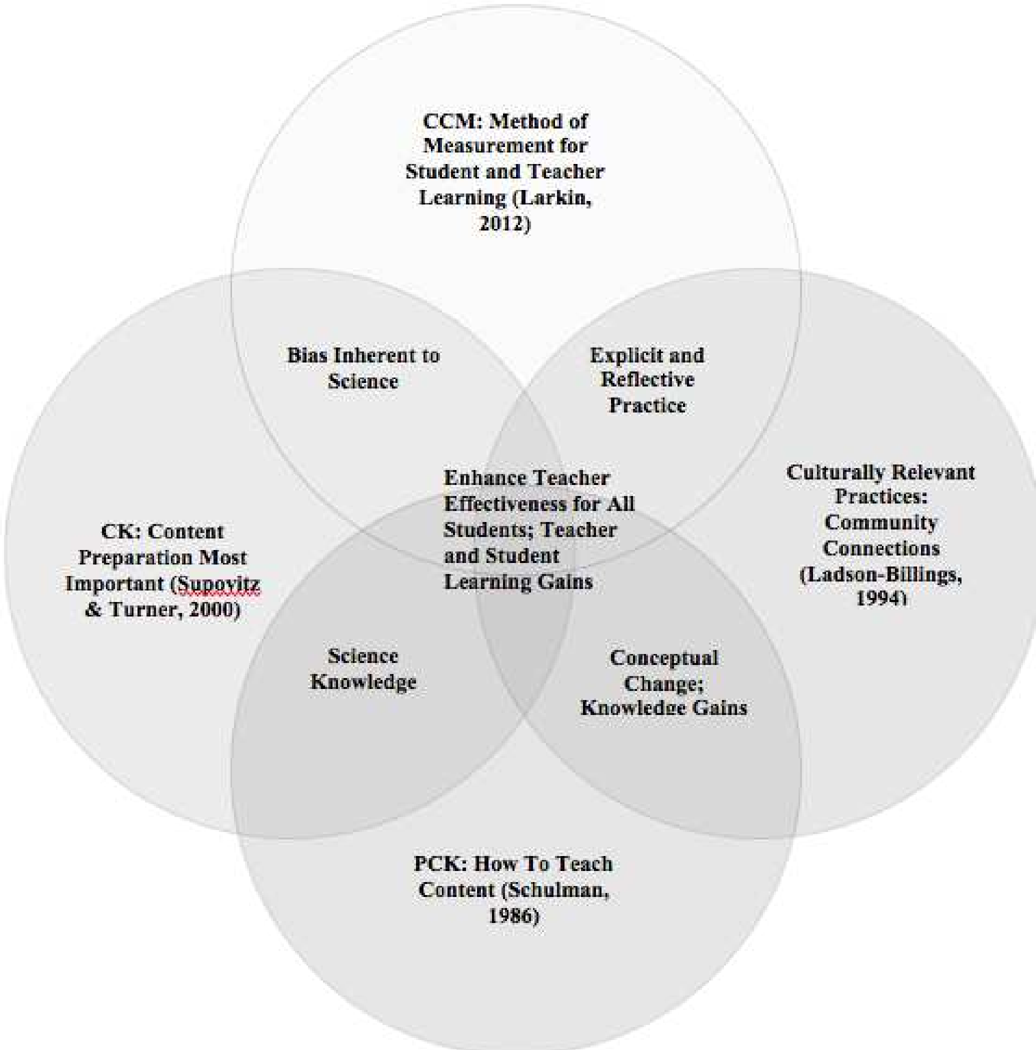

Figure 2.2. Connections and confluence of theories explored in this study.

Chapter 3: Methodology

This mixed-methods study examined three science teacher professional development programs – Students Understanding Energy (SUN), Science Education Partnership Award (SEPA), and Climate Literacy Ambassadors (CLA) – to determine:

- How the design and delivery of three science teacher summer professional development programs shaped teachers learning outcomes, and any subsequent translation into classroom practice(s);
- Any alignment with Ladson-Billings (1994) tenets of culturally responsive practices (CRP); and
- How teachers' learning outcomes were measured by summer professional development programs.

Quantitative data was collected and analyzed from teachers' post-survey results regarding program evaluation and teacher self-efficacy, from a document analysis of each program description, design, objectives, and from teacher responses to a culturally responsive practice survey. Qualitative data was obtained from teacher responses to focus group questions solicited from participants in each program. The independent variable for this study was the level of CRP implemented in the program and the dependent variables were (1) how the PD was delivered (e.g. on-site, online), (2) the nature of the activities pursued (e.g. program objectives), (3) the duration of the PD (e.g. one week, one weekend), (4) the nature of the content (e.g. CK, PCK), (5) teacher reflection on self-efficacy concerning both (a) implementation of CRP (e.g. survey and focus group) and

(b) implementation of the content learned (e.g. teacher evidence of program integration), and (6) continued support (Lawless & Pellegrino, 2007).

Teacher-learning outcome(s) concerning science content and pedagogical content knowledge were also explored. The amount of teacher content knowledge, PCK, and CRP self-efficacy gains were analyzed through teacher surveys that were administered by each program as well as by teacher responses to focus group questions and a Google Form survey concerning culturally responsive practices. Focus group questions and details about the surveys are shared later in this chapter.

The amount of CRP present in any document or piece of work was measured using a scale of: low (1-2 elements present), medium (3-4 elements present), and high (5-6 elements present). It was possible to use this form of measurement because each element of CRP is equal to the other elements. Detailed in the literature review, elements of CRP and teacher self-efficacy in implementing them are:

- Evidence of students helped to be intellectual leaders in the classroom,
- Evidence of learning community in the classroom,
- Evidence of students' real-life experiences legitimized,
- Evidence of literacy – literature and oratory,
- Evidence of engagement in collective struggle against the status quo, and
- Evidence of teachers cognizant of themselves as political beings (Ladson-Billings, 1994; Richards, Brown, & Forde, 2006, pp.7-11).

A more detailed description of how documents were analyzed is shared later in this chapter.

The unit of analysis for this study is both at the program level with document analysis for each program (SUN, SEPA, and CLA) and at the teacher level with (1) teacher post-survey data provided by each program along with (2) teacher focus group responses and (3) teacher survey responses.

Selection of a Research Design

The quasi-explanatory sequential design method used the results of each program's post-survey results as well as document analysis of program description, design, and objectives to inform and build teacher focus group questions. Only teacher post-survey data was collected because this study focused on teacher learning outcomes, rather than teacher learning growth. A mixed-methods approach was chosen for this study because both quantitative and qualitative sources of evidence were available to address the research question. In order to examine how effective each program was with respect to teacher learning outcome(s) and any translation into classroom practice, qualitative evidence in the form of teacher focus groups and evidence submitted (either electronically or hard copy) that documented program translation into the classroom was collected and analyzed. Furthermore, since the level of culturally responsive practice was an important construct for this study, it was measured through program document analysis, teacher post-survey data from each program, and through a validated CRP survey. Each program was analyzed individually, and then compared to the others to identify effective elements of science teacher professional development. Quantitative measurement alone would not answer the research question because it would not show evidence of teacher program integration in the classroom, nor would it provide evidence in the form of teacher responses to CRP questions in focus group sessions. Figure 3.1

illustrates the coherence between the two approaches used in this study: qualitative and quantitative.

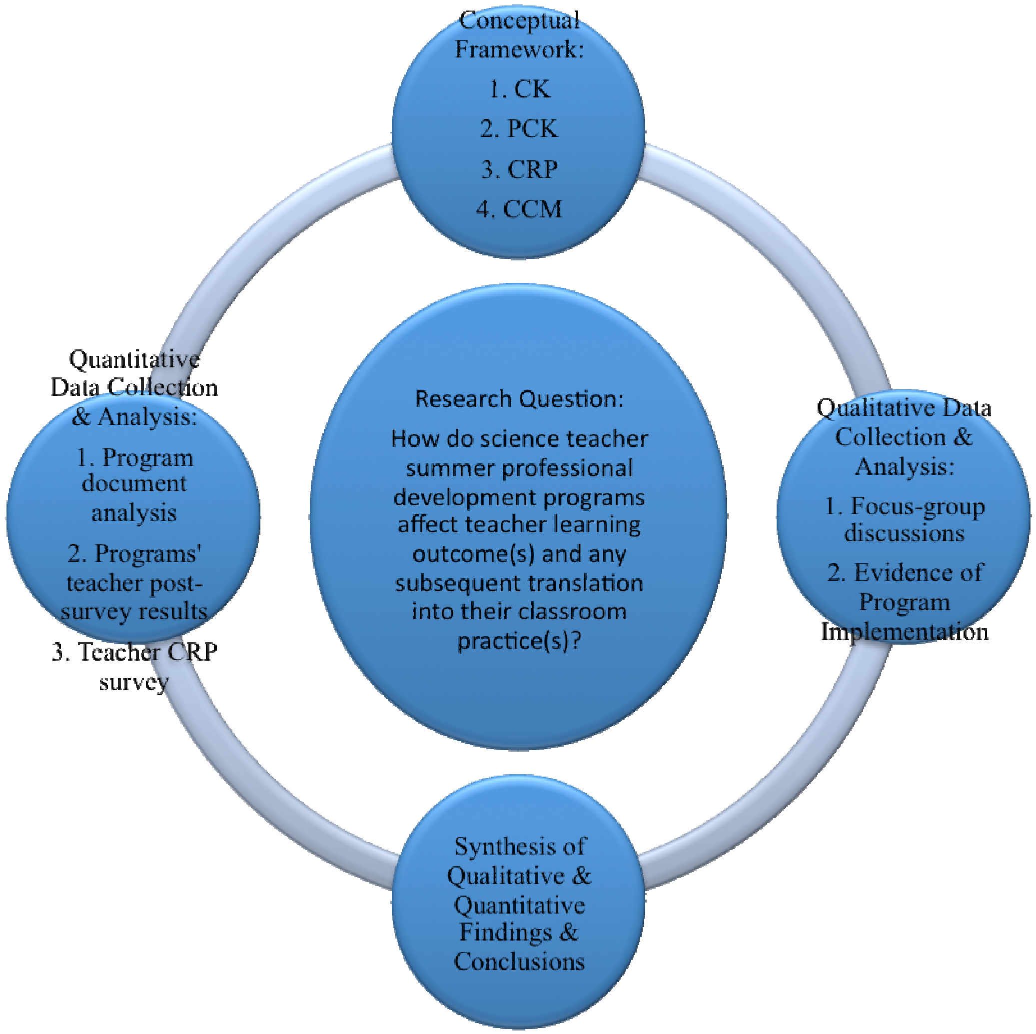

Figure 3.1. Coherence between qualitative and quantitative approaches.

Selection of Methodological Tools

Various forms of measurement were used in this study to triangulate the effects of science teacher PD with teacher learning outcome(s). Document analysis, program post-survey results, teacher focus groups, and teacher CRP survey results were all used in this study.

Existing program data. Existing program data for SUN, SEPA, and CLA were analyzed. SUN was completed in 2011 and did not received funding to repeat the program for a high school study (Batiza, 2013); therefore, current data was not available for analysis; rather, teacher-learning data from knowledge assessments conducted by SUN was used in this report based on one published study. SEPA has analyzed teacher survey data each year since 2010 in the form of pre-/post-survey results. 2012-2013 SEPA data was analyzed in this study because 2013-2014 data will not be available until after this research has been completed. Finally, CLA collected teacher data from 2010-2014, and was also presented and analyzed in this study.

Teacher learning outcome data and analysis with inferential statistics. Significant teacher learning outcomes are a goal of participation in PD programs. However, teacher-learning outcomes that enhance student-learning outcomes is missing in many PD programs and needs to be explored. Programs that offer both teacher- and student-learning outcomes to their participants invite other PD designers to replicate their methods so that all students can experience a rise in achievement. Less time will be wasted on half-day or all day, district-run PD workshops when the essential elements of effective PD are learned. As such, inferential statistics will be used to examine teacher-learning outcomes obtained from teacher post-survey results.

The null hypothesis for this study is that there is no significant difference between the three types of professional development explored, namely SUN, SEPA, and CLA, in terms of teacher learning outcomes. The alternate hypothesis for this research study is that there is a significant difference between the three types of professional development explored, namely SUN, SEPA, and CLA, in terms of teacher learning outcomes. All three programs are based in science and aim to provide greater clarity to the subject matter. SUN provides modeling activities to students – hands on manipulative equipment; SEPA provides a research experience working with living organisms, guest speakers, and a research conference; CLA provides an iPad loaned to teachers to use that includes apps for students to explore, online continued learning, and professional support. All three programs provide time for teachers to make connections between the program and their science curriculum.

The alpha level for this study is set at 0.05. A 0.05 alpha level is common in educational research – smaller alpha levels are routinely used in medical research where the chance of Type I error needs to be extremely small because of the direct possible effect(s) on human health. I was able to obtain six participants from SUN, six participants from SEPA, and four participants from CLA. There were problems obtaining teachers for this study – three teachers from SUN, two from SEPA, and three from CLA cancelled participation in the study after things in their personal lives complicated their ability to reschedule their missed focus group date/time. Measures of central tendency (mean, median, and mode) for teacher-learning outcomes have also been reported.

After the data was collected from a Google Form Survey concerning CRP, inferential statistics were used to examine correlations between program design and

teacher self-efficacy at integrating CRP. Measures of central tendency were computed to summarize data for the CRP data set. Measures of dispersion were computed to understand the variability of scores for the CRP data set. Any significant correlations were analyzed for alignment to the constructs of science teacher PD, CK, PCK, and CCM. Tables 3.1-3.3 detail how these data was organized.

Table 3.1. Measures of Central Tendency: Teacher Self-Efficacy Ratings Regarding CRP

Program	Sample Size N	Mean M	Standard Deviation SD
SUN			
SEPA			
CLA			

Table 3.2. Correlations in the Data Set for SUN, SEPA, and CLA

Program	Correlation between program design and teacher self-efficacy at integrating CRP
SUN	
SEPA	
CLA	

Table 3.3. Programs' Alignment to PD, CK, PCK, & CRP Constructs

Program	Alignment to PD	Alignment to CK	Alignment to PCK	Alignment to CRP	Alignment to CCM
SUN					
SEPA					
LEAF					

It is hypothesized that if a PD program is aligned to the constructs above, then the program will show significant teacher-learning outcomes because the constructs identify effective teacher PD design and a structure for student learning.

Care was taken to not generalize the results of this study to alternate student populations. In educational research, there is a large range of student achievement abilities across schools in the United States. The complexity of different schools and

different student populations lends itself to questioning the value of effect sizes in studies that compare the results of students from such various backgrounds.

Document analysis. As mentioned above, a document analysis of each program's curricula and delivery structure was completed using the constructs of (1) science teacher PCK, and CK (Wilson & Berne, 1999; Supovitz & Turner, 2000; Schulman, 1986), (2) culturally responsive practice(s) (Ladson-Billings, 1994), and (3) CCM (Larkin 2012). The document analysis assesses each program's design and structure in relationship to the theoretical model – Professional Development that Expands Teachers' Content and Pedagogical Content Knowledge along with Culturally Responsive Teaching and use of the Conceptual Change Model. Second, data was collected and analyzed from each program during delivery of the professional development. These data included post-tests and/or post-surveys conducted by each program.

The program description, design, and objectives for SUN, SEPA, and CLA were analyzed to gain insight into the structure of each program. Documentation of each program's design and objectives were compared to Ladson-Billings' (1994) tenets of culturally responsive practices and Larkin's (2012) CCM to observe whether or not the programs addressed the needs of urban students, and whether or not the programs included explicit and reflective practices – all of which have been shown to effectively achieve conceptual change in the minds of educators, and have moved teachers beyond traditional practices in the classroom (Larkin, 2012).

A document analysis was also done to examine any alignment to existing knowledge about effective science teacher PD, CK, and PCK (Wilson & Berne, 1999; Supovitz & Turner, 2000; Schulman, 1986). Science teacher PD, as discussed previously,

has been shown to be effective when the PD creates a community of learners with participating teachers, and addresses subject-matter knowledge (Wilson & Berne, 1999; Supovitz & Turner, 2000). Programs that obtain all aspects of effective science teacher PD, CK, PCK, and culturally relevant practices with explicit and reflective methods of measurement in learning outcomes have the potential to lead to positive gains for both students and teachers. Analyzing SUN, SEPA, and CLA for alignment to the constructs would enable future PD planners to incorporate similar structure and design into their programs.

To collect documents for analysis, emails were sent to program directors of SUN, SEPA, and CLA requesting each program's (1) objectives, (2) schedule, (3) teacher learning data, and (5) program description. The chart below was used to document each program's data. Another chart documents each program's alignment to science teacher PD, CK, PCK, CRP, and CCM (Supovitz & Turner, 2000; Schulman, 1986; Ladson-Billings, 1994; Larkin, 2012). Tables 3.4-3.8 illustrate how I marked and charted my analysis of the collected documents.

Table 3.4. Document Analysis of Three Science Teacher PD Programs

Program	**Objectives (Nature of the Content)**	**Schedule (How the PD is Delivered and Pursued, Duration)**	**Method(s) of Measuring Teacher Learning**	**Program Description**
SUN		Duration: Delivery of PD:		
SEPA		Duration: Delivery of PD:		
CLA		Duration: Delivery of PD:		

Table 3.5. Document Analysis' Alignment to Science Teacher PD (Supovitz & Turner, 2000)

Program	**Evidence of Immersion in Inquiry**	**Length of Time in PD**	**Evidence of Experience(s) Ground in Teacher's Experiences with Students**	**Evidence of Deepening Teacher Content Knowledge**	**Connection to State Standards**	**Connection to School Change**
SUN						
SEPA						
CLA						

Table 3.6. Document Analysis' Alignmentn to Pedagogical Content Knowledge (Schulman, 1986)

Program	Knowledge of Subject Matter for Teaching	Representing and Formulating Subject…Comprehensible to Others	Knowledge of Conceptions, Preconceptions, Misconceptions	Strategies to Address Misconceptions
SUN				
SEPA				
CLA				

Table 3.7. Document Analysis' Alignment to Culturally Reponsive Practices (Ladson-Billings, 1994)

Program	Evidence of Students helped to be Intellectual Leaders in the Classroom	Evidence of Learning Community in the Classroom	Evidence of Students' real-life experiences legitimized	Evidence of Literacy – literature and oratory	Evidence of Engagement in Collective struggle against status quo	Evidence of Teachers cognizant of Themselves as Political Beings
SUN						
SEPA						
CLA						

Table 3.8. Document Analysis' Alignment to CCM (Larkin, 2012)

Program	Reflective Practices – Relating to culturally responsive practices	Explicit Practices – relating to culturally responsive practices
SUN		
SEPA		
CLA		

Focus group data and analysis. A richer understanding of science teacher professional development, content knowledge, pedagogical content knowledge, culturally responsive practices, and the conceptual change model was achieved by triangulating the program centered data with teacher reflections and measures of self-efficacy through

focus groups. Teachers who completed SUN, SEPA, or CLA, and who volunteered for this study were asked to participate in one, 45-minute focus group. The focus groups took place via a conference call per participant request – teachers expressed concern over using SKYPE as an alternative. There was an initial expectation to have one focus group per program; however, teacher-scheduling conflicts prevented that. The focus groups were broken into smaller, sub-groups. One to three teachers attended each focus group. In total, SUN had three focus groups, SEPA had three focus groups, and CLA had four focus groups. The date/time for each focus group was proposed through a Meeting Wizard, and then confirmed by email. SUN focus groups took place on March 12, 2014 at 4PM, March 19, 2014 at 6PM, and March 20, 2014 at 4PM. SEPA focus groups took place on March 25, 2014 at 4PM, March 26, 2014 at 4PM, and March 27, 2014 at 4PM. Originally, a third program out of the University of Wisconsin – Steven's Point was going to be used; however, because no interested parties responded to an email invite, other programs were pursued. Six programs were contacted, and CLA expressed immediate interest – offering to contact their list of past teachers in an effort to help find participants for this study. CLA focus groups took place on April 21, 2014 at 5PM and 6PM, April 29, 2014 at 5PM, and May 6, 2014 at 10:45AM.

In early March, prior to any focus group, a list of focus group questions were piloted with five teachers from the science department at a large, urban high school to determine whether or not the questions were reliable and valid – i.e. questions asked what they intended to ask and questions were consistent with their interpretation. A few teachers suggested re-wording the ending of the questions to make it clear to teachers that their responses were to be focused on whether or not the program affected their practice.

Several changes were made, then shared again with the teachers piloting the questions. The teachers agreed with the changes. Document analysis was also used to help modify focus group questions that were adapted from Bandura's (2006) teacher self-efficacy scale for things that cause difficulty for teachers. Bandura's (2006) survey was chosen as a question set because it has been used in past research, and is an established instrument. Things that create difficulties for teachers align to the many reasons why teachers leave the profession, among them are connections to content knowledge, pedagogical content knowledge, and reaching a diverse student population – all of which are constructs analyzed in this study. The focus group questions used in this study are found in Appendix B.

Professional development that addresses the difficulties teachers in urban settings face has the potential to also help teacher retention, particularly in districts that face high levels of teacher attrition (Lankford, Loeb, & Wyckoff, 2002). According to Lankford, Loeb, & Wyckoff (2002) "low income, low-achieving and non-white students particularly those in urban areas, find themselves in classes with many of the least skilled teachers" (p.38). "Salary… class size, preparation time, facilities, [and]…characteristics of the student body" were among the main attractions for obtaining and retaining teachers (p.39). And, because teacher self-efficacy is "intimately tied to the curriculum for students of such diverse groups as learning disabled and English Language Learners" (Sleeter, 2005, p.14), the form of measurement was used to ascertain any influence on teacher practice from each PD program. Figure 3.2 illustrates the connection between things that create difficulties for teachers (Bandura, 2006) and the constructs examined in

this study, namely content knowledge (CK), pedagogical content knowledge (PCK), and culturally responsive practices (CRP).

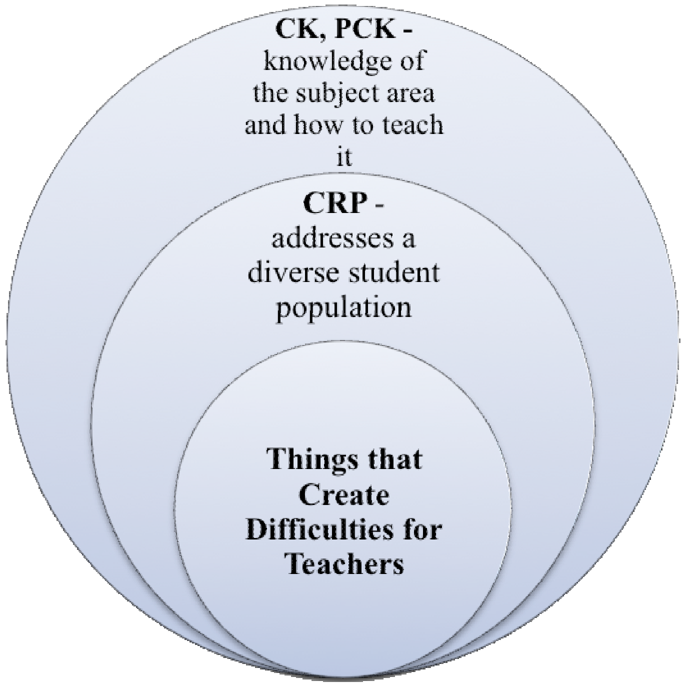

Figure 3.2. Constructs of the present study and things that create difficulties for teachers.

Teacher responses in each focus group were tape recorded and transcribed. Transcribed reports were sent out to participants to review for any concerns. Transcribed reports were analyzed for common response(s). Teacher focus group responses were read and re-read to confirm and/or modify patterns in the data set. Codes were assigned to the data set. Identifying the frequency each theme helped in identification of patterns in the data set.

Teacher surveys. After each focus group, teachers received an email asking them to complete two, anonymous Google Form Surveys – one concerning demographic and socioeconomic status information and another specifically concerning culturally

responsive practices in relation to the program attended (SUN, SEPA, CLA). The demographic survey is found at the following link: https://docs.google.com/forms/d/1Zu7p-V184vfDLMaQ9ZrOxEt4JCYCGMIbUBN68dx6dLs/viewform?usp=send_form The CRP survey is found at the following link: https://docs.google.com/forms/d/1QYRtnHStbbsN-fKLatC7cHoIgG4hVesozglqUYdHwCk/viewform?usp=send_form

The result of the demographic survey allows data to be presented in relation to participating teachers' level of education as well as the student body served.

Table 3.9. Teacher/Student Demographic & SES Information for Each Program Within the Present Study

Program	Teacher Gender	Teacher Ethnicity	Teacher Race	Highest Education Completed by Teacher	Total, Annual Household Income of Teacher	Ethnicity of Students Served	Race of Students Served	% Student Population on Free/Reduced Lunch
SUN								
SEPA								
CLA								

The use of various methodological tools in this study provided a means to triangulate results. Figure 3.3 illustrates the coherence among the selected tools.

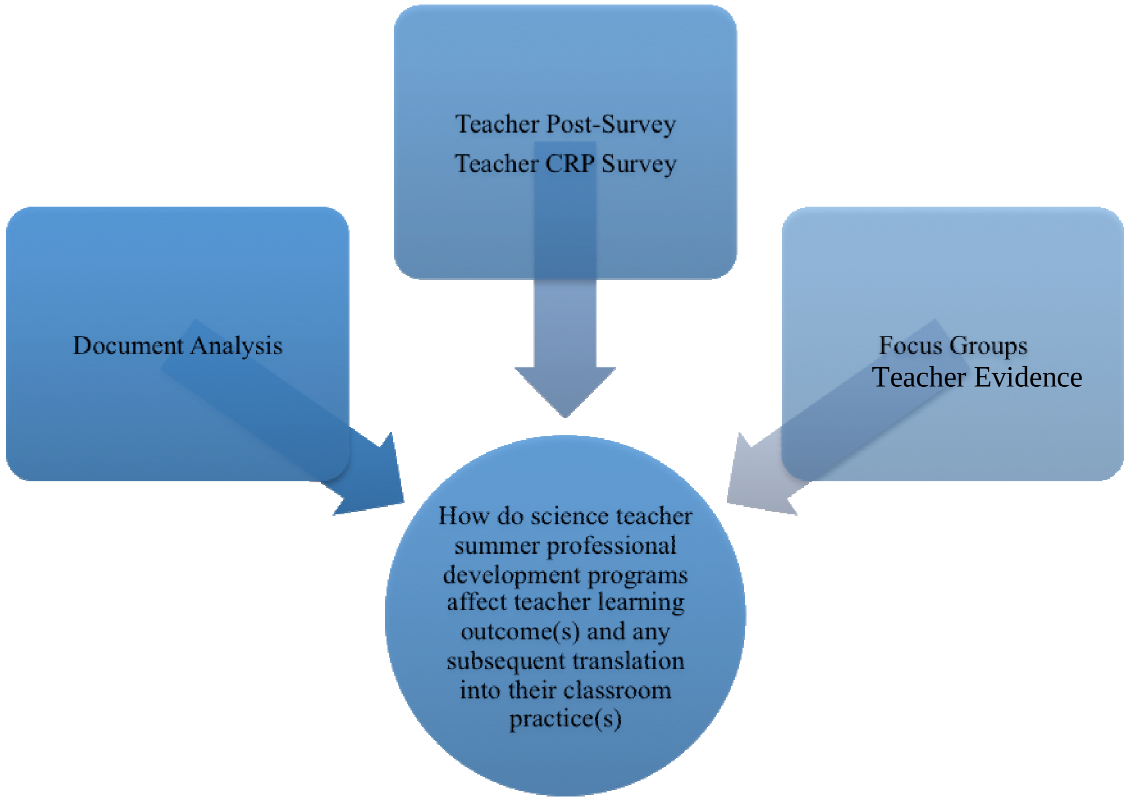

Figure 3.3. Coherence among the selected tools.

Test Validity

Test validity refers to how well the test measures what it is supposed to measure. Various forms of test validity are cited in literature and fall under two main categories: construct validity and criterion-related validity. Below is a discussion of the two main types of validity, along with classification of sub-categories within each type and how they apply to this study.

Construct validity. When the operation reflects its construct, construct validity is achieved. In this study, culturally responsive practices are defined in Figure 1.4, and a validated instrument is used to measure teachers' self-efficacy beliefs on culturally responsive practices as a result of program participation (Coston, 2010). Thus, the operation reflects the construct. A form of "truth in labeling," construct validity makes sure that the measurements that are used appropriately assess the concepts that are involved in the research project (RMKB, *Idea of construct validity*, 2006).

Triangulation also helps to capture the full breadth of the concept. Triangulation is achieved in this study through the exploration of document analysis, teacher focus groups, program post-survey analysis, teachers' evidence of program integration with their students, and teacher CRP survey responses. Results of the analysis are found in Figures 4.2 – 4.8. Face validity is achieved in this study because the CRP teacher survey is an established instrument that supports the construct of CRP "on face value" (RMKB, *Measurement validity types*, 2006). Use in prior research adds to the credibility of the assessment, as well as its apparent face validity. The criteria that define the construct of CRP are outlined in Figure 1.4 (Ladson-Billings, 1994).

Criterion-related validity. Next to proper definition and measurement of the

construct lies proper choice in the operation. Criterion-related validity checks the performance of the operation against some criterion" (RMKB, *Measurement validity types*, 2006). In other words, does the operation behave the way it should given the researcher's theory of the construct? The following sub-categories support criterion-related validity and are discussed in relation to this study: predictive validity, concurrent validity, convergent validity, and discriminant validity.

Predictive validity. By assessing how the operation predicts what it should theoretically be able to predict, a study achieves predictive validity (RMKB, *Measurement validity types*, 2006). For example, an increase in the level of CPR program integration is expected to be correlate to an increase in teacher self-efficacy for CRP, and it is ($p = 0.013 \leq 0.05 = \alpha$, $r = 0.665$). The assessment correctly predicted something that, in theory, it was able to predict, and this study achieves predictive validity.

Concurrent validity. An "operationalization's ability to distinguish between groups that it should theoretically be able to distinguish between" defines a second type of criterion-related validity – concurrent validity (RMKB, *Measurement validity types*, 2006). Because concurrent validity shows the ability of a test to discriminate between similar groups, concurrent validity adds more power to a statistical test (RMKB, *Measurement validity types*, 2006). Concurrent validity is achieved in this test, and is shown with the Kruskal-Wallis H Test. With $p = 0.019 < \alpha = 0.05$ for Item 11. The three PD programs are shown to have significant difference in their results for Item 11 on the CRP survey.

Convergent validity. Using a correlation coefficient to examine how similar one operationalization is to another operationalization that it should, in theory, be similar to,

is one way that convergent validity can be measured (RMKB, *Measurement validity types*, 2006). Correlations that identify convergent validity are observed in this study, and are observed in Figure 4.54, with r = 0.665 and p = 0.013 < α = 0.05. Because both the CRP program documents and the CRP survey were used to operationalize teacher self-efficacy, convergent validity is achieved.

This study's inclusion of construct validity and criterion-related validity makes it credible to designers of science teacher professional development. The constructs are well defined, as are the methods used measure the constructs. The validity of measurements ensures quality in research design.

Test Reliability

A study cannot have validity without reliability. Reliability refers to the consistency, or repeatability, of measurement (RMKB, Reliability, 2006). To increase the reliability of measures – random or systematic – pilot testing is done of instruments to receive feedback from respondents, trained interviewers or observers so that they do not introducing error. Data is also double-checked, and statistical procedures are used to adjust for measurement error. Using multiple measures of the same construct that triangulate the data also helps to ensure reliability (RMKB, *Measurement error*, 2006). The following are types of reliability that can be found in this research study, and that give credibility to the research findings.

Inter-rater reliability. The degree to which different observers give consistent estimates of the same phenomena, inter-rater reliability aims to decrease the human error that exists in data (RMKB, Types of reliability, 2006). While there are not multiple readers in this data set, the data was examined and re-examined for consistency in coding

for the focus group analysis. The data was coded following transcription and then re-coded one-week later to allow time to pass between coding.

Internal consistency reliability. In this study, teachers participated in a focus group that measured aspects of culturally responsive practices through a lens of things that create difficulties for teachers, and completed a survey that measured CRP. The internal consistency of the focus group and the CRP survey, add to repeatability in methods and reliability of results.

Relationship Between Validity and Reliability

Reliability is the consistency of measurements, and validity is the accuracy of measurements. Reliability can be achieved without validity because a researcher can repeat an experiment and get similar results – valid or invalid (i.e. measuring what the researcher intended or not). However, only when the results of a study show both consistency and accuracy of measuring the construct of interest, will advancements in knowledge and practice be realized.

Selection of Participants

Three programs were analyzed in this study: SUN, SEPA, and CLA. Programs were chosen out of the researcher’s own interest in how science teacher PD structure, design, and objectives varied among SUN and SEPA. The third program was difficult to find – both in terms of program directors agreeing to allow the evaluation and obtaining participants. CLA program directors gladly accepted the opportunity and had interested parties volunteer to participate.

SUN was a two-week workshop with two, bi-annual regional meetings, a classroom visit, common half-day meeting, and interactions with project staff. Teachers

attended the workshop at the Milwaukee School of Engineering and were provided with hands-on materials during the workshop, and class-sets to take with them for students to use. Group work and teacher reflections concerning concepts that were learned during the program, along with a performance assessment and lectures on content were utilized at the workshop. Teachers were provided a stipend, graduate credits, materials to take back to the classroom, and online interactive tools. Recruitment for participation in SUN occurred via an email to interested high school, biology teachers. Teachers were asked to apply to the workshop and were informed later if they had been accepted into the program.

SEPA is a one-week, summer workshop offered at the University of Wisconsin – Milwaukee and the School of Freshwater Sciences. Year-long support, personal meetings with teachers and students, materials, and an annual student research conference are staples to the structure of this program. While in the workshop, teachers participate in hands-on learning of science and pedagogy related to environmental education. Lectures on science content as well as group work and reflection are also utilized throughout the workshop. Teachers who participated in the program were provided with a stipend, graduate credits, and materials to bring back to the classroom. To recruit teachers for this program, emails as well as fliers were sent to high school science teachers that instruct life science courses. Teachers applied to the program and were notified whether or not they were selected to participate.

Teachers who participated in the CLA program attended a one-day or two-day workshop during the summer at a University. The program has been held at both the University of Wisconsin – Milwaukee and the University of North Carolina – Chapel

Hill. An on-line course was also offered to participants in an effort to develop “web-based professional development course” that met the climate program’s low-carbon objective (Ackerman & Mooney, 2014, p.3). While in the program, teachers experienced hands-on use of iPad Apps related to program objectives as well as lecture on climate change. Teachers were also loaned an iPad for one school year, received college credit and a stipend, and were provided with online classroom resources. To recruit teachers for CLA, emails and fliers were sent to middle and high school science teachers. Participants were notified whether or not they were selected to participate in the study.

In an effort to obtain teacher participants for this study, an email was sent to program directors asking them to disseminate it to past teacher participants via email in February 2013. Teachers were asked to email their interest, and in return for their participation, were provided a $10 Starbucks gift card. Due to the difficulty in obtaining teachers for this study, all teachers who expressed a level of interest were invited to participate in this study. One of the teachers from SEPA and one of the teachers from SUN no longer taught high school science. One of the teachers from CLA instructs middle school science, not high school science. Another teacher from CLA instructs math at a community college, but was asked by CLA program directors to participate in the program due to the teacher’s genuine interest in science and choice to integrate science content into mathematics lesson plans.

Email was used to confirm participation in the program; one teacher inquired about the study via a phone call. Teachers were sent an electronic copy of an adult consent form, and were asked to sign and return the form. After confirmation of participation in this study was sent via email to interested teachers, optional dates and

times for the focus groups were presented via a Meeting Wizard. Multiple dates were chosen and confirmed via email due to the inability to choose one date/time per program per focus group. Teacher schedules varied, and in the case of CLA, teachers tried to scheduled their focus group across various time zones and were unable to identify a common time to meet. Focus groups were held using a conference call due to three teacher's requesting the form of media over SKYPE. Teachers called into a number and the focus group was tape-recorded. An email was sent to teachers following each focus group that thanked participants and that outlined the remaining teacher requests: (1) complete an online demographic survey, (2) complete an online culturally responsive practice survey, (3) send evidence of program integration in the classroom, and (4) send a mailing address for the Starbucks' gift card. Participants were then mailed a thank you note and gift card.

Protection of Human Subjects

The Institutional Review Board at UWM approved this study with Exempt Status under Categories 1 and 2 (see Appendix A) on January 27, 2014. This study is approved for three years until January 6, 2017. There were no changes to the research study since IRB approval.

Researcher's Role in the Research Process

The three programs studied in this report were examined because of the researcher's own curiosity concerning variations observed in teacher professional development. After nine years of teaching at the high school level, and a myriad of PD experiences undertaken, the researcher questioned the effectiveness of PD on teacher learning and any subsequent translation of that learning in the classroom. SEPA and SUN

are two programs that the researcher has been a participant, and personal gains in teacher and student learning were observed as a result of participation in both programs. Before the study was completed, personal bias expected positive teacher responses for SUN and SEPA. While the researcher did not participate in CLA, a colleague was a participant in the program. Use of the iPad and data from online resources proved to be a new, positive element in teaching; as a result, positive comments about the program were expected for CLA.

As a result of this study, the researcher was able to identify various ways programs integrate CK and PCK, as well as variation in CRP. Subtleties in program evaluation and design, the ways in which programs measure their data, and the time and passion that go into PD design was unrealized before analyzing the three programs. Appreciation for SEPA, SUN, and CLA program designers and support staff was magnified as a result of this analysis.

Significance of the Study

Teacher professional development (PD) is a significant aspect of school science reform in the United States (Garet, Porter, Desimone, et al., 2001). Constructors of effective teacher PD programs must read the literature to find successful and unsuccessful methods of program structure and analysis so that teachers can experience programs that will lead to significant gains in their own learning, as well as possible learning gains for students (Garet, Porter, Desimone, et al., 2001). Science teacher education programs and science teacher PD is slow to change. For example, culturally responsive practices have been shown to be successful with urban youth, but are rarely used in such classrooms (Johnson & Fargo, 2009). The National Research Council (NRC) recognizes the

importance of culturally responsive methods, and calls for equity in the quality of education offered to *all* students (NRC, 2012). However, even with research showing gains and the government acknowledging such practices, science teacher PD tends to focus on the science (Johnson & Fargo, 2009). Furthermore, while much is learned through qualitative studies (Calabrese Barton & Yang, 2000), quantitative research provides correlations that often go unexplored in educational research.

There are many PD opportunities available to science educators. Ranging from an hour-long workshop to months of research at a University laboratory, and the structure of PD varies as well. Program objective(s) may cover pedagogical content knowledge and culturally responsive practices, or may only cover content knowledge. Delivery of program objectives can range from instructors of PD modeling effective practices to instructors lecturing about effective practice. Effective PD can lead to substantial changes in teacher knowledge and in student learning (Batiza et al., 2013), but the qualities of effective PD remain disputed. “Relatively little systematic research has been conducted on the effects of professional development on improvements in teaching or on student outcomes” (Garet et al., 2001, p.917). Many PD opportunities claim to cause change in teacher and student learning, but their statements are based on faulty research designs that do not have accurate or consistent methods of measurement (Garet, Porter, Desimone, et al., 2001). “Although some researchers are beginning to examine the effects of professional development on teaching and learning, few studies have explicitly compared the effects of different characteristics of professional development” (Garet et al., 2001, p.918).

Student learning is directly tied to teacher effectiveness (Cone, 2009). To ensure

quality science education for *all*, science teacher PD has to implement structure(s), objective(s), and design(s) identified in scientifically valid and reliable research reports to be effective. For NGSS to be realized, change has to take place in the analysis, and interpretation, of PD data (NRC, 2012).

Methodology Timeline

The following charts (Figures 3.4-3.7) illustrate the timeline for this study. Recruitment of participants began in February 2014, along with piloting and modification of focus group questions. In March 2014, teacher focus groups began and responses were transcribed in May 2014. Following data collection (document analysis, teacher post-test results, and teacher focus group responses), data analysis examined relationships between a program's level of culturally responsive practice (CRP) and teacher learning outcomes. It was hypothesized that increased levels of CRP in science teacher professional development leads to increased teacher learning outcomes –in terms of teacher content knowledge and pedagogical content knowledge concerning all learners.

Time Frame	Objective(s)	Data Collected
February 2014	Fliers were sent to SUN, SEPA, & CLA participants	List of participants
February 2014	Requests were sent to program directors of SUN, SEPA, & CLA for description(s) of (1) program objectives, (2) program structure & (3) program design	Documents for analysis
February 2014	Requests were sent to program directors of SUN, SEPA, & CLA for any data collected during the program (i.e. pre/post tests/surveys) for students and teachers	Program data for evidence of student/teacher learning
Early March 2014	Modifications were made to focus group questions based on document analysis	
Early March 2014	Piloted Questions for Focus Group	Pilot focus group questions to make sure questions are yielding the appropriate data – i.e. responses surround CK, PCK, CRP, and CCM in relation to each program's influence on teacher practice

Figure 3.4. Phase 1: Recruitment of participants.

Time Frame	Objective	Data Collected
Early March 2014	Program Document(s) were analyzed	Analysis for program alignment to (1) PD (2) CK, (3) PCK, (4) CRP & (5) CCM (See Figures 3.1 – 3.8 for organization of data)
March 2014 – May 2014	Requests were sent out to teacher participants (those who responded to the fliers) for evidence of program integration with their students (i.e. lesson plan, unit test, project, etc.)	Evidence of teacher integration of the program
March 2014 – May 2014	Focus groups were conducted for each program	Focus groups were tape recorded
May 2014	Focus groups were transcribed	Transcribed reports

Figure 3.5. Phase 2: Data collection timeline.

Time Frame	Objective	Data Collected
May 2014	Evidence of teacher learning outcome(s) were analyzed (self-efficacy scale)	Measures of central tendency, Kruskal-Wallis H Test, correlations
May 2014	Focus group transcripts were coded	Focus group responses were analyzed for patterns; re-read and analyzed again for confirmation of patterns

Figure 3.6. Phase 3: Data analysis timeline.

May 2014 – June 2014	Triangulated data	Looked for connections between document analysis, student pre-/post- results, teacher focus group responses, and teacher survey responses as to connections with (1) PD, (2) CK, (3) PCK, (4) CRP & (5) CCM
March 2014 – May 2014	Thank you note was sent to program participants	$10 Starbucks gift card and thank you note sent to program participants

Figure 3.7. Phase 4: Triangulation of data.

Chapter 4: Results

The purpose of this study was to examine three, science teacher professional development programs to assess whether or not degrees of culturally responsive practices (CRP) are evident within each program's structure, design, and delivery. Further analysis of the degree to which CRP is integrated within the program was analyzed for its effect on teacher learning outcomes as a result of participation in the program. This study used program document analysis, program teacher post-survey responses, focus group analysis, and CRP survey analysis to find answers to the following three research questions:

1. How does the design and delivery of science teacher summer professional development programs, namely SEPA at UW-Milwaukee, SUN at M.S.O.E., and CLA at UW-Madison, shape what teachers learn and any subsequent translation into classroom practice(s)?
2. How do science teacher summer professional development programs (SEPA, SUN, and CLA) align with Ladson-Billings (1994) tenets of culturally responsive practices?
3. How are teachers' learning outcomes measured by summer professional development programs (SEPA, SUN, and CLA)?

The conclusions reached from these three research questions should inform practitioners of science teacher professional development programs regarding design, delivery, and objectives so as to help teachers successfully integrate, for all students, what is learned at the PD opportunity. The gender, race, ethnicity, socioeconomic status of teachers who

participated in this study was of interest, and asked in a short, demographic, online survey. Participation in the survey was voluntary for teachers who participated in this study, and the results are presented below.

Who Engages in Teacher Professional Development?

Teachers who participated in this study were asked to complete a Google Form Survey that identifies demographic information for both the teachers and the student populations that they serve. While teachers were encouraged to participate in the survey, they were also informed that the survey was voluntary, and allowed to skip questions that they did not feel comfortable answering. Five of the six participants from SUN, four of the six from SEPA, and all four from CLA completed the demographic survey. A repeated attempt was made to request the remaining teachers (one from SUN and two from SEPA) to complete the survey; however, there were no responses to the requests. Furthermore, it is important to note that one of the CLA participants does not instruct high school science; rather, he instructs mathematics at a community college, but chooses to participate in science professional development and to integrate science applications with his mathematics program.

The majority of respondents are female (nine out of 13). Two out of the 13 respondents identified themselves as having Hispanic or Latino ethnicity with the remaining 11 respondents identifying as non-Hispanic or non-Latino. One teacher identified him/herself as Black or African American and one as Ashkenazi Jew, the remaining teachers identified themselves as White. 11 teacher respondents indicated completion of graduate school, while two indicated undergraduate school as the highest level of schooling they had completed. In response to what student populations the

teachers served, a majority of teacher respondents indicated not-Hispanic or not-Latino, White students (69%), followed by Black or African American (15%) and Other (15%). Finally, four teacher respondents indicated 21-30% of their students are on free or reduced lunch, three indicated five teacher respondents indicated 81-100% of their students are on free or reduced lunch, and only two teacher respondents indicated that less than 1% of their students are on free or reduced lunch. Table 4.1 summarizes the demographic information of the respondents.

Table 4.1. Teacher/Student Demographic & SES Information for Each Program Within the Present Study

Program	Teacher Gender (F:M)*	Teacher Ethnicity	Teacher Race	Highest Education Completed by Teacher (U:G)**	Total, Annual Household Income of Teacher***	Ethnicity of Students Served	Race of Students Served	% Student Population on Free/Reduced Lunch
SUN	3 F: 4 M	100% Not-Hispanic, Not-Latino	100% White	1 U: 3 G	1: $150+; 2: $100-149; 1: $50-59	100% Not-Hispanic, Not-Latino	1 Mix: 3 White	1: <1% 2: 21-30%; 1: 41-50%
SEPA	2 F: 2 M	100% Not-Hispanic, Not-Latino	100% White	0 U: 4 G	1: $100-149; 1: $50-59; 1: $40-49; 1: $30-39	75% Not-Hispanic, Not-Latino; 25% Hispanic or Latino	2 Black or African American: 2 White	1: 21-30%; 1: 31-40%; 2: 81-90%
CLA	3 F: 1 M	50% Hispanic, Latino: 50% Not-Hispanic, Not-Latino	50% White, 25% Black or African American, 25% Ashkenazi Jew	0 U: 4 G	2: $100-149; 1: $90-99; 1: 40-49	25% Not-Hispanic or Not-Latino; 75% Hispanic or Latino	1 Latino: 3 White	1: <1%; 3: 91-100%

*F = Female; M = Male; **U = Undergraduate; G = Graduate; ***Household income listed in thousands

The majority of SUN teachers who participated in this study were White, Not-Hispanic, Not-Latino, completed Graduate School, and served a student population that matched their ethnicity and race. SEPA Teachers who participated in this study were also White, Not-Hispanic, Not-Latino, and completed Graduate School, with the majority of teachers (75%) serving a student population that is Not-Hispanic, Not-Latino, and half serving students who are Black or African American and half serving students who are White. Finally, 50% of CLA teachers who participated in this study identified themselves as Hispanic or Latino, and 50% as Not-Hispanic or Latino, 50% identified as White, 25% as Black or African American, and 25% as Ashkenazi Jew. All CLA teacher participants for this study completed graduate school, and the majority (75%) serve a student population that is Hispanic or Latino with 91-100% of the students on free or reduced lunch – the highest of all three programs.

It is interesting to note that the majority of teachers who participated in this study from SUN teach White, Not-Latino students, while the teachers from SEPA and CLA who participated in this study teach a more ethnically and racially diverse student population. Perhaps, if the teacher volunteers from SUN had instructed a more diverse student population, responses during the focus group and culturally responsive practice survey would have been different. The small sample sizes for each program offer insight into each program, but also limit any generalization to the larger population of teacher participants for SUN, SEPA, and CLA.

A second point of interest from the demographic survey results is the variation in amount of students receiving free or reduced lunch among the three programs. CLA teachers reported the highest level – three out of four CLA teachers who participated in

this study indicated 91-100% of their students receive the assistance. Whereas, SUN teachers reported the lowest level – three out of four SUN teachers indicated 30% or less of their students receive the assistance. Again, a larger sample size might have indicated a higher percent for SUN or a lower percent for CLA. Teacher and student demographic information helps in understanding the data because it categorizes homogenous groups and the possibility of skewed results. Teacher participants also completed an online survey that explored how each program prepared them in the instruction of culturally responsive practices. Results of the CRP survey are now explored.

Culturally Responsive Practice Self-efficacy Scale: Measures of Central Tendency

Teachers who participated in this study completed a self-efficacy scale regarding how confident they felt the program prepared them to integrate culturally responsive practices with their students. Five of the six teachers from SUN, four of the six teachers from SEPA, and all four teachers from CLA participated in the survey. A repeated attempt via email was made requesting the remaining teachers (one from SUN and two from SEPA) to complete the survey; however, there were no responses to the request. The survey used is a validated instrument (Coston, 2010), and the survey questions are found in Appendix C. SPSS was used to produce a summary of the data collected from the CRP survey; the results are outlined in Table 4.2.

Table 4.2. Measures of Central Tendency: Teacher Self-Efficacy Ratings Regarding CRP

Descriptive Statistics

	N	Range	Minimum	Maximum	Mean		Std. Deviation	Variance	Skewness		Kurtosis	
	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic	Statistic	Statistic	Std. Error	Statistic	Std. Error
SUMofResponses	13	199.00	145.00	344.00	272.7692	19.21243	69.27139	4798.526	-.929	.616	-.475	1.191
Valid N (listwise)	13											

Notably, 92% of respondents expressed high confidence ("quite a bit" to "a great deal") that the program (SUN, SEPA, CLA) prepared them to meet the needs of their students, to assess student learning using various types of assessment, and to use students' prior knowledge to help make sense of new information. It is important to note because these results show that each program had an effect on teachers' ability to help the student population they serve. However, recall the demographic variation among the teacher sample – the majority of student diversity among participating teachers was found in SEPA and CLA programs. Gathering a larger sample for this study would aid in understanding how homogenous each program truly was, and how effective each program was concerning preparing teachers for CRP.

Additionally, 100% of teacher respondents expressed high confidence ("quite a bit" to "a great deal") that the program (SUN, SEPA, CLA) prepared them to use a variety of teaching methods. This is significant because, again, each program has shown to have an effect on teacher learning outcomes – specifically with how to meet the needs of students, construct alternate forms of assessment, use prior knowledge to aid in student understanding, and vary teaching methods. To see whether or not there was a significant level of difference among the programs with the questions asked in the CRP teacher self-efficacy survey, the Kruskal-Wallis H Test was utilized. Results of the test are found below.

Teacher Self-efficacy and Culturally Responsive Practices

The Kruskal-Wallis H Test was used to test the null hypothesis for this study, that the level of confidence teachers felt programs (SUN, SEPA, CLA) prepared them to instruct culturally responsive practices are the same for each program. The alternate

hypothesis is that there is a difference between the three programs regarding the level of confidence teachers felt they were prepared to utilize culturally responsive practices. Kruskal-Wallis tests the significance of group differences between two or more groups; however, it only determines if there is a difference between the groups, it does not tell which program is different. The Kruskal-Wallis test was chosen because the measurement does not meet the normality assumption of an ANOVA and because there were an unequal number of subjects reporting from each program ($n = 5$ for SUN, $n = 4$ for SEPA, $n = 4$ for CLA). SPSS was used to produce the results to the Kruskal-Wallis H Test and is represented in Table 4.3. Survey data was collected from teacher participants over the course of a month, from April 15, 2014 through May 15, 2014. As stated earlier, a validated instrument, the CRP Survey (Coston, 2010), was used and responses were kept anonymous.

Table 4.3. Kruskal-Wallis H Test

Descriptive Statistics

	N	Mean	Std. Deviation	Minimum	Maximum
SUMofResponses	13	272.7692	69.27139	145.00	344.00
Program	13	2.0000	.81650	1.00	3.00

Ranks

	Program	N	Mean Rank
SUMofResponses	SEPA	4	6.25
	SUN	5	7.00
	CLA	4	7.75
	Total	13	

Test Statistics[a,b]

	SUMofResponses
Chi-Square	.297
df	2
Asymp. Sig.	.862

a. Kruskal Wallis Test

b. Grouping Variable: Program

Table 4.4. Median Test Results

Frequencies

		Program		
		SEPA	SUN	CLA
SUMofResponses	> Median	1	3	2
	<= Median	3	2	2

Test Statistics[a]

	SUMofResponses
N	13
Median	305.0000
Chi-Square	1.130[b]
df	2
Asymp. Sig.	.568

a. Grouping Variable: Program

b. 6 cells (100.0%) have expected frequencies less than 5. The minimum expected cell frequency is 1.8.

The assumption for the same shape for the treatment distributions was checked and distributions were symmetrical. The samples were taken randomly and independent of each other, and because the data did not fit the ANOVA assumptions, the Kruskal-Wallis H Test was chosen to compare the three samples (Hole, n.d.). As stated earlier, the null hypothesis reads the level of confidence teachers felt instructing culturally responsive practices as a result of participation in the program is equal. The alternate hypothesis is that none of programs are equal in teacher self-reports concerning CRP. The significance level for this test is $\alpha = 0.05$; therefore, the null hypothesis is rejected if the p-value ≤ 0.05. Since the p-value $= 0.862 > 0.05 = \alpha$, we fail to reject the null hypothesis. At the $\alpha = 0.05$ level of significance, there is not enough evidence to conclude that there is a difference in the teacher responses among the three programs.

Check for errors. A type I error is the incorrect rejection of a true null hypothesis. The researcher rejects the null hypothesis, but the treatment actually has no effect (Gravetter & Wallnau, 2009). This can occur if the sample is a misrepresentation of the population. Perhaps, even though a random sample was selected, an extreme sample was chosen rather than one that is representative of the population. The treatment may have shown a strong effect on the extreme sample, but does not have an effect on the true population (Gravetter & Wallnau, 2009). Even though the treatment does not have an effect on the true population, because the sample data fell into the critical region(s), the researcher rejects the null hypothesis and makes a Type I error. Type one errors are serious because they “lead to false reports in the scientific literature…[and]… other researchers’ time and resources may be wasted” in exploring the results of a false report (Gravetter & Wallnau, 2009, p.242).

To decrease the chance of a Type I error, a 0.05 alpha level was chosen. Alpha levels determine the probability of a Type I error because define the boundaries for the critical regions – regions where unlikely events will occur. “The alpha level for a hypothesis test is the probability that the test will lead to a Type I error” (Gravetter & Wallnau, 2009, p.243). An alpha level of 0.05 means that there is a 5% risk of a Type I error (5% chance that the null hypothesis was rejected, but it that it should have failed to be rejected). In comparison, an alpha value of 0.00001 would substantially decrease the chance of a Type I error, but would require substantial change in the sample data for it to reach the critical regions and show an effect of the treatment (Gravetter & Wallnau, 2009). Alpha levels of 0.05, 0.01, and 0.001 are often used as a balance between low chances of Type I error as well as decreasing “excessive demands of the research results” (Gravetter & Wallnau, 2009, p.245). A 0.05 alpha level is common in educational research – smaller alpha levels are routinely used in medical research where the chance of Type I error needs to be extremely small because of the direct possible effect(s) on human health.

A type II error is the failure to reject a false null hypothesis (Gravetter & Wallnau, 2009). “The treatment effect…exists, but the hypothesis test fails to detect it” (Gravetter & Wallnau, 2009, p.243). “The sample mean is not in the critical region even thought the treatment has had an effect on the sample” (Gravetter & Wallnau, 2009, p.243). Type II errors occur when the effect of the treatment is small (Gravetter & Wallnau, 2009). Not as critical as Type I errors, Type II errors are found in reports that do not recognize the treatment effect to be large enough to detect any difference between the control and experimental groups (Gravetter & Wallnau, 2009). Null hypotheses and alternate

hypotheses indicate whether the level of evidence is sufficient enough to conclude change(s) in treatment effects. Type I errors incorrectly identify a change from treatment, and type II errors fail to identify an effect that was present. Type I errors lead to a false report that will directly affect other researchers and/or human health. Type II errors indicate that there is not enough evidence to conclude treatment effect. While a change in alpha level affects the likelihood of a Type I error, the likelihood of type II errors is defined by beta (ß) – a probability that is associated with the power of the test (Gravetter & Wallnau, 2009). Modifications can be made to an experiment that will decrease the likelihood of a Type II error and increase the power of the test (Gravetter & Wallnau, 2009). ANOVA has more power than Kruskal-Wallis; however, the assumptions for ANOVA were not followed for this study. The sample size for this study is also small ($n = 13$), which decreases the power of the test.

SUN teacher participants for this study represent a homogenous group, with most being White, Not-Latino, and instructing White students, very few on free or reduced lunch (<30%). Therefore, for SUN teachers, an extreme sample may have been selected which could lead to a Type I error. A Type I error in this study means that while there may be a noticeable effect on teacher instruction as a result of program participation in the sample, there might not be a noticeable effect on teacher instruction in relation to the entire population of SUN teacher participants. However, SUN data on all teacher participants shows that this is not the case (Batiza, Gruhl, Zhang, et al., 2013). Significant gains in teacher content knowledge and self-efficacy were shown in the SUN study of the entire teacher population. In comparison, SEPA and CLA teacher participants also had a small sample, but were more heterogeneous in ethnicity, race, socioeconomic status and

student population served. The number of sample size for CLA was also smaller than the sample size for SUN and SEPA, which may have inflated the significance of CLA’s effect on teacher CRP self-efficacy, and led to a Type I error. Further analysis of each program’s structure, design, and objectives gives further insight into the effect each program had on teacher CRP self-efficacy and is explored below.

The Program’s Structure, Design, and Objective(s)

Each program (SUN, SEPA, CLA) submitted documents that outline structure, design, and objectives. The documents were analyzed for each, and also looked at for any integration of culturally responsive practices as defined by Ladson-Billings (1994). The structure of each program is summarized in Table 4.48 and culturally responsive practices found within each program are outlined in Table 4.49.

Table 4.4. Document Analyses of Three Science Teacher PD Programs

Program	**Objectives (Nature of the Content)**	**Schedule (How the PD is Delivered and Pursued, Duration)**	**Method(s) of Measuring Teacher Learning**	**Program Description/ Significance**
SUN	• "To help teachers become aware of why and how energy transfer occurs during cellular respiration and photosynthesis" (Batiza, n.d., p.1) • "To build teacher self-efficacy…regarding their knowledge of these concepts, their ability to teach them, and their confidence in the ability of their students to learn them" (p.1) • "To provide teachers with classroom sets of tools…and initial curricular lessons they could either use outright or adapt for use in the classroom" (p.1)	Duration: Two-week workshop; two, bi-annual regional meetings; a classroom visit; common half-day meeting; interactions with project staff (Batiza, n.d.) Delivery of PD: Hands-on use of the materials provided for classroom use; group work and teacher reflection (also shared reflection) of concepts learned; performance assessment; guest speakers, lectures on content	• Teachers "generate[d] a daily record of concepts learned during the workshop" (Batiza, n.d., p.1) • Bi-annual regional meetings for reflection • All teachers were given a performance assessment regarding CR and PS using the materials provided for classroom use • Group challenges used to re-visit concepts learned • Students evaluated the materials used in the classroom	The program was developing and testing "a new conceptual approach and new curricular materials regarding the biological energy transfer processes of cellular respiration and photosynthesis" (Batiza, n.d., p.1)
SEPA	• Develop skills of inquiry for "doing and understanding environmental health science" (Petering & Berg,	Duration: One-week in summer at UW-Milwaukee and Great	• Year-long formative and summative evaluation	"Connects teacher educational enhancement with

	n.d., p.1) • Content Knowledge • Science Education Pedagogy (PCK) • Community Outreach – connections made at Great Lakes WATER Institute	Lakes Water Institutes; Year-long support; Personal meetings with teachers & students; Annual student conference <u>Delivery of PD:</u> Hands-on learning of science and pedagogy related to the environmental education modules; lectures on science content; group work	• Teacher reflection and discussion of the workshop	directly related student activities involving in-depth authentic experimentation and various modes of scientific communication" (Petering & Berg, n.d., p.5)
CLA	• "Advance climate literacy" (Ackerman & Mooney, 2014, p.1) – deepening content knowledge • "Facilitate climate education with minimal carbon emissions…[using] web-based resources and Internet interactions" (p.1) • "Infuse NASA satellite derived climate data into G6-12 climate education" (p.1)	<u>Duration</u>: 1 and 2-day workshops; on-line course <u>Delivery of PD:</u> "web-based professional development course" due to low-carbon objective (Ackerman & Mooney, 2014, p.3); hands-on use of iPad Apps; lecture	• Evaluation surveys that "asked teachers to rate their level of agreement/disagreement regarding each Essential Principle of Climate Literacy" (Ackerman & Mooney, 2014, p.5) • On-line quizzes based on content knowledge • End-of-Project Survey – self-efficacy scale rating	• "Use the teacher workshops and on-line climate curriculum to 'seed' a network of a self-sustained learning community" (Ackerman & Mooney, 2014, p.3) • "Rather than require educators to design a

			to determine teachers' confidence level in preparing and conducting lessons concerning the Essential Principles of Climate Science (p.7)	student research project or purchase equipment to conduct research, CIMSS would loan iPads to teachers for a full school year. Using iPads, students could collect data and participate in short-term investigations" (Ackerman & Mooney, 2014, p.4)

Document analysis shows all three programs utilizing a hands-on design with teachers, whether with models (SUN), experimental modules (SEPA), or iPad Apps (CLA). Furthermore, all three programs incorporate deepening of the content knowledge: photosynthesis and cellular respiration (SUN), environmental health (SEPA), climate literacy and data analysis (CLA). However, the structure (two-week (SUN), one-week (SEPA), on-line (CLA)) and objectives for each program vary. While SUN aims to help teachers with content knowledge (CK) and pedagogical content knowledge (PCK), SEPA adds community connections and inquiry skills. On the other hand, CLA solely focuses on CK and data analysis with iPad Apps. SUN and SEPA both indicate teacher reflection in their methods of analysis, and SUN and CLA utilize teacher self-efficacy as a method of measurement to determine teachers' learning outcomes. Table 4.5 summarizes any alignment the programs show in relation to culturally responsive practices.

Table 4.5. Document Analysis' Alignment to Culturally Responsive Practices (Ladson-Billings, 1994, pp.117-118)

Program	**Evidence of Students helped to be Intellectual Leaders in the Classroom**	**Evidence of Learning Community in the Classroom**	**Evidence of Students' real-life experiences legitimized**	**Evidence of Literacy – literature and oratory**	**Evidence of Engagement in Collective struggle against status quo**	**Evidence of Teachers cognizant of Themselves as Political Beings**
SUN	Yes	Yes	No	No	No	No
SEPA	Yes	Yes	Yes	Yes	No	No
CLA	No	No	No	No	No	No

Document analysis of the three programs, shows SEPA having the highest integration of culturally responsive practices at four, SUN second highest with two, and CLA the lowest with zero. Tables 4.6-4.8 summarize aspects of professional

development, pedagogical content knowledge, and the conceptual change model in relation to the three programs studied.

Table 4.6. Document Analysis' Alignment to Science Teacher PD (Supovitz & Turner, 2000)

Program	**Evidence of Immersion in Inquiry**	**Length of Time in PD**	**Evidence of Experience(s) Ground in Teacher's Experiences with Students**	**Evidence of Deepening Teacher Content Knowledge**	**Connection to State Standards**	**Connection to School Change**
SUN	No	Two-weeks; one-year commitment	Yes	Yes	Yes	Yes
SEPA	Yes	One-week; one-year commitment	Yes	Yes	Yes	Yes
CLA	No	1-2 days; one-year commitment	Yes	Yes	Yes	Yes

All three programs (SUN, SEPA, CLA) utilize many factors known to be effective for science teacher professional development. The SUN Program's objective to focus on conceptual change and the CLA Programs' objective to focus on data analysis are not the foci of Supovitz & Turner's (2000) element of immersion in inquiry.

Table 4.7. Document Analysis' Alignment to Pedagogical Content Knowledge (Schulman, 1986)

Program	**Knowledge of Subject Matter for Teaching**	**Representing and Formulating Subject…Comprehensible to Others**	**Knowledge of Conceptions, Preconceptions, Misconceptions**	**Strategies to Address Misconceptions**
SUN	Yes	Yes	Yes	Yes
SEPA	Yes	Yes	Yes	Yes
CLA	Yes	Yes	Yes	Yes

All three programs address Schulman's (1996) identified effective practice of pedagogical content knowledge. SUN, SEPA, and CLA utilize a hands-on approach for teachers to explore content knowledge. SUN offers time during the workshop for teachers to discuss, reflect, work together, and develop lessons using the new materials provided by the program. SEPA provides group time for teachers to discuss practice and use of the material. SUN and SEPA also utilize past teacher participants as mentors to future years. CLA has provided an on-line site for teachers to share lessons they have developed. Table 4.8 identifies each program's alignment to Larkin's (2012) conceptual change model.

Table 4.8. Document Analysis' Alignment to CCM (Larkin, 2012)

Program	**Reflective Practices – Relating to culturally responsive practices**	**Explicit Practices – relating to culturally responsive practices**
SUN	No	No
SEPA	No	Yes
CLA	No	No

While SUN uses teacher reflection outside and within group discussions as a form of evaluation for teacher learning outcome(s), and SEPA uses teacher reflection during group discussion as well, none of the programs relate reflection specifically to culturally responsive practices. Further, while SEPA explicitly discusses varying levels of environmental toxicity within and among cultures, there is no evidence within the documents from SUN and CLA to support explicit methods in relation to culturally responsive practices.

Interestingly, SEPA was the only program to show a high level of CRP integration by documenting four out of six culturally responsive practices. SEPA was

also the only program to incorporate part of Larkin's (2012) conceptual change model in relation to culturally responsive practices by explicitly referencing community outreach through tours of the Great Lakes WATER Institute, a science research conference that incorporates local environmental organizations, and lectures on the disparities found within environmental health issues.

Also of interest, one of the goals for CLA was a type of community outreach research project; however, 92% of CLA teachers reported not participating in "a climate mitigation project as a result of participating in [the program]" (Ackerman & Mooney, 2014, p.11). And, while SUN had extensive use of teacher reflection concerning content knowledge throughout the program, connection to culturally responsive practices was not made during the reflections. SEPA, SUN, and CLA all showed to be effective in influencing teacher learning outcomes; however, whether or not teachers' learning outcomes could have incorporated practices that support student learning focusing on urban districts as well, remains to be seen. Teachers completed program surveys post participation in SUN, SEPA, and CLA. Results of the post-survey results are documented below.

Each Program's Post-survey Results

SUN, SEPA, and CLA each submitted teacher post-survey results to this study. SUN provided documents from a published report (Batiza, Gruhl, Zhang, et al., 2013), SEPA and CLA both provided their own end of year evaluation reports (Goldberg & Associates, 2013; Ackerman & Mooney, 2014). An evaluation of teacher self-efficacy and change in teacher content knowledge was evident across all three programs; however, pedagogical content knowledge was more difficult to assess for both SUN and

CLA. SEPA had clear documentation of PCK in the evaluation. The results provide evidence for the concepts analyzed in this study and are summarized in Table 4.9.

Table 4.9. Programs' Evidence of Teacher Learning Outcome(s)

Program	CK	PCK	CCM	CRP
SUN	• pre-/post performance assessment using a paired-samples *t* test – "teachers significantly increased their understanding of energy transfer…and maintained a significant increase even 1 year later" (Batiza, Gruhl, Zhang, et al., 2013, p.298) • "All groups benefited from the SUN workshop, including the AP pilot group" (Batiza, Gruhl, Zhang, et al., 2013, p.299) • A large effect size from the treatment group (p.300) • Significant gains in teacher self-efficacy with the topics (p.300)	• "Both the treatment and control groups' personal belief that they could teach this topic increased significantly as a result of the workshop" (Batiza, Gruhl, Zhang, et al., 2013, p.300)	• Teacher reflection of materials used (p.295)	• None

SEPA	• 83% reported an increase in knowledge of environmental health concepts (Goldberg & Associates, 2013, p.11)	• 95% reported the workshop provided "instructional and curricular materials that address the needs of [their] students" (Goldberg & Associates, 2013, p.24) • 60% reported that the workshop provided them with "a greater understanding of ways to teach high school science" (Goldberg & Associates, 2014, p.25) • 93% of respondents "reported gaining new understanding or skill in teaching high school science using an inquiry-based approach through presenting SEPA modules" (Goldberg & Associates, 2014, p.84)	• 100% reported "discussions with…colleagues during the workshop…provided [participants] with a better understanding of how other teachers approach instruction and the teaching of science" (Goldberg & Associates, 2014, p.26) • Barriers to implementation were reported, including: "lack of resources, curriculum constraints and limited time" (Goldberg & Associates, 2014, p.85)	• "77% of teachers agreed that…students valued the opportunity to interact with other science students from other schools" (Goldberg & Associates, 2014, p.74)

CLA	• End of project survey reveals "93% of knowledge and ability to prepare and conduct lessons on each of the Essential Principles of Climate Science" (Ackerman & Mooney, 2014, p.7) • 90% reported an increase in confidence "around teaching or discussing climate change…as a result of participating in the [CLA] Project" (p.10)	• 78% report using zero to a few of the lesson plans from the Global and Regional Climate Change web page (p.10) • 42% reported using their iPad daily (p.14) • 69% reported using their iPad to daily enhance their own productivity • 77% reported using their iPad to examine teaching/learning resources (p.20) • 91% reported having their students take observations using the iPad (p.21)	• None	• 92% reported not instigating or participating in "a climate mitigation project as a result of participating in [CLA]" (Ackerman & Mooney, 2014, p.11)

As indicated in Table 4.9, SEPA shows evidence of all constructs in this study, SUN shows three of the four (CK, PCK, and some evidence of CCM), and CLA shows three of the four (CK, PCK, and the potential for CRP). It must be noted that the evidence cited is based on the reports provided by each program. There may be additional features included in each program, but not cited in the documents provided, that would add further evidence to the constructs. Additional data not explored in this study was also found in the documents. Figure 4.10 explores how the professional development opportunity was translated into the classroom.

Barriers to program integration were discussed during teacher reflections in the SEPA program. Also discussed during SEPA reflections was how other teachers chose to integrate program materials (Goldberg & Associates, 2014). As stated earlier, SUN made extensive use of teacher reflections, but reflections were based on content knowledge and pedagogical content knowledge, not on culturally responsive practices. To confirm gains in teacher learning outcomes as a result of the program, teachers who participated in this study were asked to submit evidence of program integration with their students. Results of teacher submissions are shared below.

How Teachers Implemented the Program in the Classroom

Teachers who participated in this study were asked to submit evidence of program integration with their students. Evidence could be in the form of a lesson plan, assessment, handout, reading, project, etc. Table 4.10 documents the form of evidence that was submitted by each teacher, along with any connection observed in the document(s) to CK, PCK, CRP, CCM.

Table 4.10. Teachers' Evidence of Program Integration & Connection(s) to the Constructs within the Present Study

Program	% Teachers Who Submitted Evidence	Type of Evidence Submitted	Evidence of What Construct(s)
SUN	100%	• Venn Diagram Comparison • Fill-in-blank Story of ATP • Task Outline • Quiz • Video-taped lesson • Diagrams • Worksheets • Alternate assessments • Lesson Plans • Modeling assessments • Test • Reflection of modeling experience	• CK • PCK
SEPA	100%	• Handouts for writing instruction • Power point lecture • Rubric for writing • Schedule for module(s) • Background information Handout • Student posters • Pictures of students in lab working on a module • Worksheet with Student Reflection • Lesson Plans • Community Outreach Guidelines with Rubric • Cooperative Group Exercise • Student Research Papers • Article Critique/Review	• CK • PCK • CRP • CCM

CLA	50%	• Data analysis • Mathematical application(s) • Creation of website	• CK • PCK

The type of evidence that teachers were encouraged to submit was left open to various forms. Teachers submitted a myriad of evidence from lesson plans to student papers and posters to data analysis worksheets. All three programs had teachers submit evidence confirming CK and PCK; however, only SEPA showed evidence for CRP and CCM. One of the teachers mailed documents while the other teachers submitted electronic copies.

Examples of teacher evidence that demonstrate the four constructs examined in this study are found in Appendices D – G. Demonstrations of both content knowledge (Appendix D) and pedagogical content knowledge (Appendix E) were guided by Schulman's (1986) definitions which differentiate the two constructs, and are outlined in Figure 2.1. CK refers to the amount and organization of knowledge learned, while PCK refers to how teachers are able to make the knowledge comprehensible to others (p.9). In Appendix D, a SUN teacher submitted a quiz given to students in Honors Biology. The student is asked about specific knowledge gained in the unit; therefore, this piece of evidence is categorized as CK. In Appendix E, PCK is observed in the SUN teachers' choice to use various tools to aid in students' understanding of the content; thus, addressing the requirement of making the knowledge comprehensible to others (Schulman, 1986). Culturally responsive practices are observed in Appendix F, where a teacher participant from SEPA submitted an inquiry lab on fathead minnow that asked students to choose a topic of their own interest surrounding lead, and to prepare a presentation that proposed a solution to school, community, or public health members. This evidence is directly tied to the learner-centered approach, empowering students to investigate issues related to their local community (Ladson-Billings, 1994; Basu &

Calabrese Barton, 2006). A SEPA teacher also submitted evidence that connected to the reflection aspect of Larkin's (2012) conceptual change model. In Appendix G, students are asked to reflect upon what they learned about lead poisoning. The CCM utilizes explicit and reflective practices in the examination of CRP. By having students reflect upon what they have learned in an investigation, the SEPA teacher is reinforcing with her students what was learned in the professional development program.

Submission of community outreach guidelines (Appendix F), worksheets incorporating students' reflections on the topics that were being discussed about environmental health (Appendix G), and critiquing environmental health articles support SEPA's influence on CRP and CCM in the classroom. Additionally, a few SEPA teachers submitted student work to document their own participation in the program. In particular, Appendix H demonstrates one students' personal experience with an environmental health concern – nicotine. Meanwhile, CK and PCK dominated the evidence submitted by SUN teacher participants (Appendices D and E). Data analysis was the main form of evidence submitted by CLA teacher participants (Appendix I); however, there were only four teachers from CLA who participated in this study. Of the four CLA participants, two submitted evidence of program integration. Further support for teacher learning outcomes is documented through analysis of focus groups, which were completed for each program.

Summary of Findings

Document analysis reveals that SEPA aligns to all constructs examined in this study. SUN also aligns to most of the constructs examined in this study, but contains a

lower level of CRP and is missing CCM. CLA aligns to PD, CK, and PCK, but is missing components of CRP and CCM. Summary information is observed in Figure 4.1.

Program	Alignment to PD	Alignment to CK	Alignment to PCK	Alignment to CRP	Alignment to CCM
SUN	Yes	Yes	Yes	Medium	No
SEPA	Yes	Yes	Yes	High	Yes
CLA	Yes	Yes	Yes	Low	No

Figure 4.1. Program's Alignment to PD, CK, PCK, CRP, and CCM constructs.

Major differences between the programs are found in the level of CRP implementation and alignment to Larkin's (2012) conceptual change model. SEPA's high level of CRP implementation is supported through a document analysis, teacher CRP self-efficacy survey, and program post-survey analysis. A discussion with teachers from each program was conducted to look for additional evidence of teacher learning outcomes. Results of the focus group discussions are found below.

What Teachers Learned in Their Professional Development Program?

Ten focus groups were conducted from April 2014 through May 2014 to accommodate teachers' schedules. Focus group questions were developed out of Bandura's (2006) self-efficacy scale for things that create difficulties for teachers and piloted with science teachers from Greendale High School. Modifications to teacher focus group questions were made based on the pilot as well as on document analysis. The goal of six participants per program was met for SUN and SEPA; however, the third program was difficult to establish. CLA agreed to participate in this study, and emails were sent out the past program participants. Four of the teachers who responded to the request for participates in this study completed the focus group. Additional teachers from SUN, SEPA, and CLA agreed to participate, but could not attend their scheduled focus group session. Emails were sent to teachers who missed their scheduled focus group;

however, no replies were received to reschedule. After completion of the focus groups, tape recordings were transcribed and themes were identified and confirmed with a second reading of the focus group responses.

Multiple themes were identified in the focus groups, including: increasing student understanding, increasing teacher content knowledge, enhancing student engagement, modeling, student diversity, retention, student engagement, building relationships with students, and community connections. The following are examples of each theme.

Content knowledge. Teacher content knowledge is one of the targets for professional development, and has been evidenced in program documents and program teacher post-surveys for SUN, SEPA, and CLA. Gains in teacher content knowledge were also evident during teacher focus groups, particularly for SUN, where all six participants indicated an influence SUN had on their content knowledge. Four teachers from SEPA indicated an increase in content knowledge; two teachers from SEPA indicated no change in content knowledge as a result of the program. All four teachers from CLA indicated an increase in content knowledge as a result of participation in the program. Teachers also referenced increases in student understanding, from long-term retention of photosynthesis and cellular respiration in SUN to analysis skills in SEPA.

Teacher content knowledge. Teachers who participated in focus groups indicated an increase in their own content knowledge as a result of participation in SUN, SEPA, and CLA. The following are excerpts from focus groups regarding teacher content knowledge.

> **SUN MAN 1:** “It was a much deeper, better understanding of energy, and how energy is interconnected and related to everything. And just to, you

know, look at a plant and think about the electrons moving through that plant and just creating energy, is driven by the sun."

SUN WOMAN 1: "It really connected the dots between the sun and the chloroplasts and the glucose and the mitochondria and the ATP, and so I go back to that all the time, too. And I never talked about electrons before, and now I'm talking about them all the time because, you know, it's such a, it's just such a—it's just a beautiful relationship, you know."

SUN WOMAN 3: "I was actually surprised at how little I actually knew about energy within the context of photosynthesis and cell respiration. So, yeah, I was surprised at my lack of knowledge, I guess."

SUN WOMAN 4: "I have a little bit of knowledge on a lot of things, and so I was actually able to gain a deeper understanding of just energy transfer in general, which I can now apply to not only those two units, but I also our unit on *What is Life* and start talking about ATP right off the bat. I also used it in all of my other science courses I teach, whether it's Earth Science or Meteorology or even Physical Science when we talk about almost any kind of energy. I am always using things that I learned through the SUN project."

SEPA MAN 1: "I guess, um, not a whole lot of understanding, but it reinforced a lot of things that I wanted to do."

SEPA WOMAN 1: "I think it definitely gave me some richer material to use, um dealing with, um—I'm a biology teacher, high school. That's the class I use it in, high school biology, and I think, during the genetics

lessons it really, uh, allowed for me to get a little more depth of the historical perspectives behind finding the human genome and what happens then, and how we can study certain things, but really there's never a direct cause and effect relationship. And so I thought that it was really fun."

SEPA MAN 3: "It didn't necessarily, like, change my understanding of [the content], but it allowed me to put a different slant on how I...teach…the material."

CLA WOMAN 3: "You know I can actually see that I had risen in educational work tools, and that's how I'm working kind of, of course I accessed a lot of um all of the great resources I experienced using the iPad through different kinds of research and inquiry. And I pulled together, I actually wrote a program, well I didn't write it, I designed it and hired a programmer who wrote it. And that's really changed my way of teaching climate; I do it using that program now."

SUN, SEPA, and CLA each had teacher participants who indicated an increase in content knowledge as a result of participation in the program. Gains in student understanding as a result of participation in the program were also reported.

Student understanding. Teachers suggested an increase in student understanding of the content during their focus group as well, particularly for SUN, where all six participants indicated in increase in student understanding of the processes of photosynthesis and cellular respiration as a result of participation in the program. All of the SEPA teachers also expressed an increase in student understanding, mostly as a result

of presenting a unique experimental experience for students to work with living specimen. One of the CLA teachers indicated that he teaches math at a community college, and does not focus on science content. Another CLA teacher indicated that she teaches fifth grade, and the materials provided from CLA did not fit the needs of her students. The remaining two CLA teachers indicated more data analysis for students to observe regarding climate change. Excerpts from teacher focus groups for SUN, SEPA, and CLA are found below.

> **SUN WOMAN 1:** "What…surprised me was how you can take something so complicated—really complicated—and really turn it into something that kids can wrap their heads around."
>
> **SUN WOMAN 2:** "I think it helps my students really understand the whole process of what's going on with the electrons, and what's going on with protons, you know, what's going on with the energy—that I don't think they did before because I was too vague, or it was too abstract, and I didn't have a good way to explain that."
>
> **SEPA WOMAN 2:** "It really didn't affect the content of our subject area, but it did affect my understanding of how we teach some of the science skills, um, so like, when I first found it, um, last year when I first did the first module, I did the Zebrafish module, and it was so hard for kids to write the paper because their analyzing skills were so weak."

SUN teacher participants reported the highest level of increase in student understanding with all six teachers mentioning the effect. Most reported modeling as the method having the greatest effect on increases in student understanding.

Modeling. Modeling is one of aspect of the Next Generation Science Standards (NRC, 2012), and was a present theme throughout the focus groups for SUN. Four out of six SUN teachers mentioned the positive effects modeling had on student retention of the content; the remaining two SUN teachers mentioned hands-on manipulative pieces improving student understanding of the content as well. Neither SEPA nor CLA focus groups mentioned modeling within the focus group discussions. Retention of content knowledge as a result of modeling was another aspect of the SUN program that was brought up by SUN participants, but was missing from SEPA and CLA focus group discussions.

> **SUN WOMAN 2:** "I have been more willing to, um, look at modeling as a way to get across an idea because I was, I tend to do a lot of labs and inquiry labs, but not necessarily utilizing models. And that's helping them understand."
>
> **SUN WOMAN 3:** "my experience was I had students as freshmen and then I turned around and I had them again as juniors in advanced biology. And they were really amazed at their retention, as was I, um, and so I'm very confident that what the students learned was transferred. And while they might have lost some of the details, the content went more over a significant amount of time.

Outside of content knowledge and pedagogical content knowledge, facilitating a diverse student population through culturally responsive practices has been another construct explored in this study. Teacher focus group analysis also revealed student diversity as a theme among participants from each program.

Student Diversity. In relation to how the program aided teachers' ability to instruct a diverse student body, five out of the six SUN teachers indicated that hands-on tools helped reach a wide-range of learning styles, and one SUN teacher chose not to use the models with her lower level students. Two SEPA teachers indicated that the program did not influence their ability to teach to a diverse student population because they teach higher-level advanced placement students – a very homogenous group; the remaining four SEPA teachers indicated a positive influence on their ability to teach to a diverse student population as a result of SEPA. One of the teachers from CLA indicated a strong connection between the program and instructing a diverse student body. Another CLA teacher cited the potential for reaching diverse student populations using CLA materials. The remaining two teachers did not find CLA as adding to their ability to instruct a diverse student population. Excerpts from the focus groups are below.

> **SUN MAN 1:** "Even the students who struggle the most—the models for them, really clears it up."
>
> **SUN WOMAN 1:** "I did not use the SUN material on my lower level students, which they probably would, you know, love, but I just didn't know where the students would be, so I didn't—I didn't take the steps to try it with them."
>
> **SUN MAN 1:** "For deeper understanding, in the right environment, if you get the right support anyone can learn a difficult concept. And you know, if you can get someone who I thought wasn't going to learn much to get to learn respiration and photosynthesis, then really who can't you get to

learn. It really helped that effort my academic abilities more than anything from me."

SEPA WOMAN 1: "I think [SEPA] helped overcome, um, some power dynamics, where students feel helpless, and like they can only do what they're told because of the offered opportunities for them to get creative and to choose, to choose their chemicals and think about what they're going to do. And they got really excited, they had some surprising, um, results, and they talked about it. You know, and it was kind of an easier in because you're dealing with fish instead of humans because then you don't seem quite as, um, harsh."

SEPA WOMAN 1: "[SEPA] provided opportunities to, um, be able to kind of mix up a heterogeneous group of students, who wouldn't normally work together. Um, but they all worked together [because it was] new for all of them. It…kind of like evened the playing field a little bit. So, I had a few students who worked together, and one was really active and loved to do stuff, but he did not take very good lab notes or anything like that, and then I had a quiet student who was really good at all of her book work but, um, was not comfortable taking risks. You know, she was like a well-trimmed, typical student, um, and so by pairing, by pairing those two up, and I did this before, but those two—they worked really, really well together because, um, I think she was actually thinking she was going to blame him when things didn't go right."

CLA WOMAN 3: "I have a master's degree in multicultural education and the whole CLA thing is really like multi you know, like reaching learners where they are, you know what their interest is and kind of being you know with the different learning styles and there's just such good resources out there, you can find something for everybody."

Another aspect of student diversity that was brought up in SEPA, and indirectly during SUN focus group discussions was the outlet the program provided for relationship building with students.

Building relationships with students. For teachers in the SEPA program, the experimentation exposed opportunities for them to build relationships with students. Half of the SEPA teachers mentioned some type of connection they were able to make with students as a result of participation in the program. SUN and CLA teachers did not directly mention building relationships with students during the focus groups. However, two teachers from SUN mentioned their students contacting them while in college and commenting on the positive impact working with the models had on their learning.

SEPA WOMAN 1: "What SEPA did was provide this great opportunity for me to experiment with my students, instead of giving them an experiment to do. You know, we worked side-by-side, and it was super exciting when we got the fish to lay eggs, you know, like one of those all shocked, you know, it was really a bonding experience, and one I could not have done without SEPA."

SUN WOMAN 2: "I had numerous AP students come back from college and took freshmen biology and told me that they took to the trays when

they were in my class, and it helped them remember it. That's what they remembered was the trays, and they could remember it, and it helped them in their freshmen college class. So, I mean bringing it back to anecdotal, but let me tell you I have had numerous students come back and tell me that."

Opportunities to explore living specimen and content together built partnerships with students; it also opened the door to outreach from the local community.

Community involvement. SEPA and CLA teachers indicated some level of community involvement as a result of participation in the programs. One SUN teacher mentioned a microbial fuel cell as providing the potential for community involvement, but did not pursue it. The remaining SUN teachers did not indicate community involvement as an aspect of program integration.

SEPA WOMAN 1: "We took a field trip to the water institute. So, we got to do a little tour there. We also got to go to UWM for the conference, and so in both of those situations it gave us opportunities just to be a part of a greater learning community. Um, and then, and also, um, we spent one day just checking out different rivers and the shores of Lake Michigan because students hadn't really ever thought about, um, actually they were really—they got really interested in drugs in the water, like, individual drugs in the drinking water and how that can happen and the impact it has on all of us. So, then we started to do some talking, and we just got out and kind of cruised around, and I think that was a huge impact—it got them thinking. And you know, and I'm not sure that—we didn't get to the

level of depth that it really probably changed anyone directly, but we got enough depth that they started to get interested. And really that's the key because then they have, you know they have all the answers at their hands right now with their smart phones and technologies."

SEPA WOMAN 2: "We took kids to find a solution for the impacts of lead in the community…and they were able to do that to varying degrees in connecting to the community—that was the whole idea, but they weren't all necessarily able to do that. And when they were designing the solutions, some of the kids reached out to the community to get answers and help. Um, so for example one group was talking about lead education, and then connected that to the health center in Waukesha. And another group was wondering about lead pipes in Waukesha, and they asked the Public Health Department to look at their…problems—that kind of stuff…even just listening to them about the connections and reaching out, to at least talk to some adults about what they were doing was, was good."

SUN MAN 3: "I've had probably 2 or 3 or 4 conversations with different teachers in different districts about the program—even to the point where I brought materials along and shown them kind of how to use it and, so as far as that goes, I mean to a different community, not our own community, but a different community. That has then greatly forged for just getting to know people better, and that's just a skill that I've learned through the program."

SUN MAN 3: "I could see how you could get the community involved, but I didn't use it that way."

CLA WOMAN 1: "Part of the reason I went to the training is because the whole topic of global warming and global climate change was touchy. And so now I feel like you know if a parent would come in having issues you know, "How can you teach my child about this?" I at least can say here's the data."

CLA WOMAN 3: "Whatever I'm doing I think that my CLA experience has enhanced my depth of knowledge about the areas of teaching that I am doing. So, um it does because it's just part of what makes me more interactive with the communities able to do what I do."

All three programs had teachers mention the potential for community outreach; however, only SEPA and CLA had teachers who mentioned using what they learned in the program to try a community outreach project with their students. Interestingly, SUN teachers who did mention community outreach referred mainly to a teaching community; whereas, SEPA and CLA both mentioned outreach to the surrounding area.

Summary of Themes

All three programs (SUN, SEPA, CLA) expressed at least one of the constructs focused on for this study – content knowledge, pedagogical content knowledge, and culturally responsive practices. Of the themes that emerged from analysis of focus group responses, SUN connected with an increase in teacher content knowledge, increase in student understanding of the content, modeling, and addressing a diverse student

population. Teachers from the SEPA program indicated evidence of increases in teacher content knowledge, in student understanding of the content, addressing a diverse student population, making connections with students, and community connections. The teachers who participated in CLA supported the themes of increased teacher content knowledge, addressing the needs of a diverse student population, and making community connections as a result of program participation.

All three programs had teacher participants who spoke passionately about the program they attended. One SUN teacher voiced concern that a lack of community outreach expressed during the focus group might distract from the strong, positive impact the program had on her students. A CLA teacher mentioned her master's degree in multicultural education backing the methods used by the program to educate teachers. A SEPA teacher indicated the program offered opportunities to build relationships with students. There was no evidence provided throughout the focus groups that indicated disappointment in the programs. Therefore, all three programs used in this study were effective for the science educators who participated, but are the methods effective for all science educators and for all students? The results of this study are important for designers of science teacher professional development programs because they identify aspects of teacher learning that translate into effective practices that support all students.

Limitations

This study examined three science teacher professional development programs, explored how the programs affect teacher learning, and any subsequent translation of that learning into classroom practices. The purpose of this study was not to seek casual links among these elements. Instead, I was interested in whether the tenets of CRP were

present in these programs and how they became manifest in teachers' understandings and their work with students. As such, there are several limitations to this work that I wish to point out: (a) Obtaining a third professional development program to study was challenging. Six additional programs were contacted before finding a third that had willing teacher participants. (b) The third program, CLA, had a smaller sample size than SEPA and SUN; perhaps, the difference was due to contacting teachers towards the end of the school year while they were wrapping up final grades. (c) Because the three programs did not have the same sample size, more powerful statistical tests like ANOVA were not used. Larger sample sizes of the same magnitude would have provided more powerful data. (d) A greater number of teachers responded to my invite to participate than actually participated in the study. Due to busy schedules, seven teachers were unable to follow through with the focus group request. (e) The construct of CRP is relatively new to the field of science education. Ladson-Billings' (1994) tenets of CRP, which were used to analyze each program's documents, were different from the validated, online CRP survey which teacher participants responded to following the focus group discussion. Having a defined construct for CRP instruction would have allowed for better alignment of the data. (f) Student learning was not explored due to the scope of this study; therefore direct impacts on such cannot be made. However, a study by Yager, Choi, Yager, et al. (2009) indicates that if teachers model what they learn in PD with students, student learning increases. Connections made between the present study and the one completed by Yager, Choi, Yager et al. (2009) is further explored in the discussion.

Chapter 5: Discussion

Educational reform efforts to improve students' learning outcomes are often present in teacher professional development opportunities; however, the structure and design of these opportunities varies and often focuses on a homogenous student population – White students in suburban schools. Professional development that helps science educators embrace the culture(s) found in urban settings and include the culture of the community they serve with classroom lessons will help urban youth feel connected to science (Emdin & Lee, 2012). Currently, preparation for the teaching profession includes the use of field experience(s), method and foundation courses in education, and subject matter courses in specific disciplines; however, even these aspects of pre-service teacher education vary among teacher certification programs (Roehrig & Luft, 2006; Wilson & Berne, 1999). Many PD programs are ineffective for teacher learning and for student learning (Wilson & Berne, 1999). Wilson & Berne (1999) identify effective elements of teacher PD, including:

> teacher learning…not bound and delivered but…activated,…engag[ing] [teachers] as learners in the area that their students will learn in but at a level that is more suitable to their own learning…[and] privileging… teachers' interaction with one another. (p.194-195).

Research in the field of teacher PD has been unsuccessful at bridging "teacher learning, professional development, teacher knowledge, and student learning" into one cohesive study (p.204). Therefore, the need for studies that integrate all aspects of teacher PD is

clear. Furthermore, research that examines effective science teacher PD in relation to the needs of urban students is lacking.

The No Child Left Behind (NCLB) Act (U.S. Department of Education, *Title I: Improving the Academic Achievement of the Disadvantaged*) requires that states ensure a high level of professional development for teachers, but it does not define what high-quality professional development entails (Borko, 2009). Current reform efforts to evaluate teachers include what teachers should be able to do, but do not define the type of professional development support that teachers should be exposed to in order to reach all students (DPI, 2013). “For teachers, learning occurs in many different aspects of practice, including their classrooms, their school communities, and professional development courses or workshops” (Borko, 2009). Supovitz & Turner (2000) identify six research-supported ideas concerning science teacher PD, including:

(1) teacher immersion in inquiry, questioning, and experimentation,

(2) lengthening the time teachers spend in PD,

(3) teacher engagement with experiences that are grounded in teachers’ experience with students,

(4) deepening teacher content knowledge

(5) connecting PD to state standards for student performance, and

(6) connecting PD to school change. (p.964-965)

Noteworthy, teachers from poorer schools showed the least change at reform efforts in the science classroom (p.976). Empowering marginalized youth by modeling how teachers can recognize and embrace different values, beliefs, and ways of knowing, and structuring lessons to bridge community and school stakeholders may help the typical,

White urban educator understand the needs of urban students; yet professional development is not regulated to incorporate these practices. When teachers learn about culturally responsive practices, and how to integrate CRP into classroom lessons, urban students may begin to feel more of a connection to science.

The purpose of this study was to examine three, science teacher professional development programs and to assess whether or not degrees of culturally responsive practices (CRP) were evident within each program's structure, design, and delivery. Further analysis of the degree to which CRP was integrated within each program was analyzed for its effect on teacher learning outcomes as a result of participation in the program. SEPA indicated a high level of CRP, SUN a medium level, and CLA a low level. Results of the correlation showed a strong, positive relationship between program level CRP and teacher response on the CRP self-efficacy survey. This study used program document analysis, program teacher post-survey responses, focus group analysis, evidence of teacher integration of the program with their students, and CRP survey analysis to find answers to the following three research questions:

1. How does the design and delivery of science teacher summer professional development programs, namely SEPA at UW-Milwaukee, SUN at M.S.O.E., and CLA at UW-Madison, shape what teachers learn and any subsequent translation into classroom practice(s)?
2. How do science teacher summer professional development programs (SEPA, SUN, and CLA) align with Ladson-Billings (1994) tenets of culturally responsive practices?

3. How are teachers' learning outcomes measured by summer professional development programs (SEPA, SUN, and CLA)?

The conclusions reached from these three research questions inform program designers as to essential design, delivery, and objectives that will help teachers successfully integrate, for all students, what is learned at the PD opportunity.

Findings & Interpretations

If the program includes it, teachers will learn it. This was the case for participating teachers in the three programs examined for this study. SUN, SEPA, and CLA each contained elements of effective professional development (Supovitz & Turner, 2000). Content knowledge and pedagogical content knowledge was incorporated into each program's structure, design, and objectives, and was identified as forms of teacher learning in focus groups, program post-surveys, and evidence of program integration that was submitted by teacher participants. In particular, 100% of participating teachers from SUN and CLA indicated gains in content knowledge as a result of participation in the professional development program.

The findings are consistent with literature on science teacher PD, which has been found to routinely focus on gains in teacher content knowledge (Xu, Coats, & Davidson, 2012). In 1996, the National Research Council called on science teacher professional development to focus on subject-matter knowledge and to deepen teachers' content understanding (NRC, 1996; Cohen & Hill, 1998). However, sole focus on content knowledge may fail to reach all students. An achievement gap remains in science between Hispanic and White students, and between Black and White students – with White students scoring higher on average on national assessments (NAEP, 2011).

Science teacher professional development programs that aim to reach all students must begin by addressing barriers that teachers in urban districts face on a daily basis. CK and PCK are important to PD design, objectives, and structure, but they cannot be the only focus. Science teachers need to be given ways to facilitate learning for all students to engage in and understand the content.

For example, SUN focused on modeling two of the most abstract concepts in the biological sciences: photosynthesis and cellular respiration. Teachers need development in how to teach these areas for student understanding; this need is evident in SUN teacher focus groups and in a study by Batiza, Gruhl, Zhang, et al. (2013). SUN has shown to deepen student understanding to a level that extends beyond the high school classroom. Yet, participating SUN teachers reported <30% of their student population requiring free or reduced lunch, and the majority of students White and Not-Latino. The question that arises is whether or not the methods used to instruct SUN teachers is enough to satisfy the needs of teachers in urban districts who are primarily instructing poor students of color?

Gains in student understanding market a successful professional development program, and both SUN and SEPA teacher participants mentioned gains in student understanding during focus group sessions. SUN teacher reports focused on learning through modeling and SEPA teachers focused on the analytic skills of research writing as a result of program participation. Both reports identify expectations outlined by the Next Generation Science Standards for secondary students (NRC, 2012). NGSS labels modeling as an essential performance expectation and science and engineering practice to be integrated with classroom lessons. SUN was the only program that had teachers specifically mention modeling during focus group discussions as important to their own,

and to their students' learning. Inquiry-based learning and a focus on student performance also dominate NGSS and are observed in the research writing incorporated by SEPA. Yet, how the standards will be realized in classrooms across the nation remains to be seen. Yager (1996) indicated the need for PD opportunities to help science teachers incorporate Science-Technology-Society curriculum, but teachers did not embrace the standard as much as they did the content knowledge they were expected to deliver to students (Weiss, Banilower, McMahon, et al., 2001). PD opportunities that help educators understand how to implement NGSS will greatly enhance the success of NGSS' integration into K-12 classrooms; however, whether or not NGSS' incorporation of engineering practices will address the achievement gap between majority and minority students, particularly in urban schools, in science education remains to be seen. Avoiding the problems inherent with standardized accountability measures that were observed with the National Science Education Standards (Collins, 1997) will be an important avenue for professional development programs to navigate when aiming to increase the level of understanding for all groups of students. Therefore, science teacher professional development that aims to help teachers navigate the new standards should include instruction on practices that meet the needs of all students, namely through the use of CRP.

Research on PD identifies teachers from poorer schools having the least amount of reform in the science classroom (Supovitz & Turner, 2000, pp.976). The majority of urban teachers do not understand the needs of the student body they serve – that is, incredibly diverse, and "disproportionately poor" students of color (Atwater, 1995, p.22). In the present study, participating CLA teachers identified themselves as serving the

poorest students of the three programs, with three out of four teachers reporting > 91% of their students on free or reduced lunch; and, most of the teachers did not mention gains in student understanding as a result of program implementation. However, one of the participating CLA teachers instructs middle school science and reported the level of CK too high for her students to grasp, and another CLA participant does not instruct science at all; rather, he instructs mathematics at a community college and chooses to integrate science into his lesson plans. A third CLA participant indicated she created a computer program to help her students understand climate change as a result of participation in the program; she also indicated the online lessons provided by CLA serve a multitude of learning styles. Nevertheless, only two out of the four teachers sent evidence of program implementation with their students; whereas, 100% of both participating SUN and SEPA teachers sent evidence of program implementation. Sending evidence was connected in this study to teachers' implementation of the program with their students; however, there may have been alternative reasons why two of the four CLA teachers did not submit evidence. Focus groups for CLA took place middle to late May 2013, near the end of the school year, when teachers are busy finishing grades. Thus, the time frame for CLA teachers may have distracted participants in this study. However, because student achievement is directly tied to teacher effectiveness (Bleicher & Lindgren, 2005), there is a need for science teacher PD to examine practices that prepare teachers for urban settings.

Science teacher professional development and culturally responsive practices. Building relationships and community outreach are two areas Ladson-Billings (1994) identifies as essential practices to integrate when aiming to reach urban youth. The

six tenets of culturally responsive practices were examined for each program. Of the three programs studied, SEPA had the highest rating of CRP, with participating SEPA teachers identifying CRP in their submitted evidence of program integration, and focus group discussions. However, potentially due to a small sample size, in an inferential statistics analysis, the null hypothesis that SEPA, SUN, and CLA had the same effect on teachers' ability to use a variety of teaching methods as a result of participation in the program failed to be rejected ($p = 0.862$).

In comparison, CLA reported that 92% of teachers did not participate in a community outreach project; coincidently, there is no evidence in program documentation that community outreach was a focus for the program (Ackerman & Mooney, 2014). It is expected that if there had been more emphasis and modeling of community outreach projects, teachers would have utilized the tool. Participating SUN teachers varied in their response concerning student diversity: one teacher indicated not using the tools provided by the program for lower level students, two teachers reported they taught a homogenous group of high-level learners, and did not instruct diverse learners, and four teachers indicated a positive influence on diverse learners using the tools.

Half of teacher participants from SEPA identified the program exposing opportunities to build relationships with students during focus group discussions. While SUN and CLA teacher participants did not directly mention their program in this way, two of the six SUN teachers did mention their students contacting them while in college and the positive impact the models had on their understanding. Klem & Connell (2004) identify that "students with caring and supportive interpersonal relationships in school

report more positive academic attitudes and values, and more satisfaction with school" (p.262). A strong, positive connection between student and teacher is also observed throughout Ladson-Billings' (1994) tenets of culturally responsive practices, where students are part of a learning community, supported to become intellectual leaders in the classroom, and participate in discussions against the status quo (pp.117-118). Both SEPA and SUN teachers expressed relationship building during focus groups, and relationship building was also modeled in program structure when scientists and program directors worked directly with teacher participants. Scientists also supported teachers throughout the school year. SEPA added a layer of student support by having scientists serve as guest speakers and as sounding boards for student research designs. In comparison, outside of the use of an iPad throughout the school year and the ability of teachers to access online educational resources, further support from scientists in the CLA program was not documented. Modeling relationship building in science teacher PD has the potential to transfer into classroom practices, and is an important aspect of CRP. Another area that PD experiences should model is community outreach projects. Science educators positioning themselves as active learners of their students, and as participants in the school community effectively engage students in school science and utilize CRP (Calabrese Barton & Berchini, 2013).

Teachers that aim to be insiders to the communities they serve must restructure teaching methods to meet that goal (Calabrese Barton & Berchini, 2013, pp.23-26). Further, knowing and belonging to the local community "supports teachers in noticing and leveraging students' non-dominant ways of knowing as integral to the learning process" (p.27).

> Schools that succeed in engaging families from very diverse backgrounds share three key practices. They (1) focus on building trusting collaborative relationships among teachers, families, and community members; (2) recognize, respect, and address families' needs, as well as class and cultural differences; and, (3) embrace a philosophy of partnership where power and responsibility are shared. (Henderson & Mapp, 2002, p.7)

Both SEPA and CLA had respondents indicate some type of community involvement as a result of participation in the program. One SUN teacher mentioned the possibility of community outreach through a microbial fuel cell, but had not pursued this form of student learning with program materials. In comparison, SEPA program documentation identified teachers going on a field trip to a local School of Freshwater Sciences and discussing potentially controversial issues in environmental health. CLA also took on a controversial issue – global climate change. Through data analysis and online resources, the program provided tools for teachers to spark a discussion that had potential to cause change in the school and the local community. Community outreach may not have been the goal of SUN, but it had the potential to move beyond process modeling, and spark discussions of alternative energy sources. By explicitly modeling community outreach to their participants, science teacher PD has the potential to see this practice transferred into classroom lessons. Greater community involvement may show greater interest in science by all students.

A need to reach all types of learners is evident in the literature. Science teachers are to "recognize and respond to student diversity when planning, guiding, and facilitating student learning" (Collins, 1997, p.304). The "culture of power" found in

school science often prevents minority populations from participating (Calabrese Barton & Yang, 2000; Delpit, 1988). For millions of educators across the Nation, PD that models effective practices that prepare teachers for student diversity may begin to address the achievement gap present in academia. Perhaps, CRP will aid in this endeavor. What and how a program chooses to measure teachers' learning outcome(s) serves as an indicator for what the program values. Explicit and reflective practices were observed in SUN and SEPA; however, only SEPA documents and teacher evidence of program integration also showed discussions explicitly tied to community concerns.

How science teacher PD measures teachers' learning outcomes. Both SUN and SEPA implemented a high level of teacher reflection throughout their program. In a document analysis, SUN gathered teacher reflections on changes in content knowledge and pedagogical content knowledge throughout the workshop; however, there is no evidence of the reflection's ties to culturally responsive practices. Conversely, SEPA's reflections occurred during group discussion by program evaluators and transferred into classroom practice with worksheets concerning student reflections of controversial topics surrounding environmental health disparities. The modeling of explicit health concerns during the program, and teacher group reflection of how they will use the information in their classroom successfully made its way into classroom lessons. Neither reflection nor explicit practices were found in CLA documentation, during teacher focus groups, or in evidence of program integration. According to program post-survey data, CLA evaluators focused on the technology borrowed to educators – iPads, Apps, and their effects on teacher learning. The results of program measurement appear to have an effect on what is transferred into classroom practice. SEPA modeled explicit discussion of CRP, and the

practice re-surfaced in teacher lesson plans and worksheets. Therefore, designers of PD should not only consider implementing CRP in their program structure, design, and objectives, but should also consider how they will measure teachers' implementation of the practices.

Effective elements of professional development have been identified in the literature (Supovitz & Turner, 2000). Left out of the discussion are practices that meet the needs of all students. While teacher content knowledge and pedagogical content knowledge are important areas to address in summer programs, modeling effective practices for a diverse student population through culturally responsive practices may cause more of an impact on student understanding than CK and PCK alone. The following provides recommendations to policy makers and professional development designers as to what can be done to ensure the needs of marginalized youth are not left out of PD opportunities.

Recommendations

Sykes (1996) identified problems in teacher professional development as "the most serious unresolved problem for policy and practice in American education today" (p.465). An achievement gap in science remains between Hispanic and White students, and between Black and White students – with White students scoring higher on average on national assessments (NAEP, 2011). Ladson-Billings (1994) focused on identifying best practice in her work with successful teachers of African-American students. Choosing to focus on best teaching practice rather than telling a 'good story' of successful African American students, Ladson-Billings (1994) calls upon all teachers to begin incorporating CRP practices with their students. In a comparative study, Yager,

Choi, Yager et al. (2009) identify Science-Technology-Society (STS) curriculum benefiting 4th-, 5th-, and 6th-grade students when compared to traditional textbook-based instruction. While many teachers are reluctant to change practices due to either (1) unfamiliarity with the practice(s), or (2) fear that the new practice will take away from content mastery, the study showed no significant difference in content mastery between traditional and STS instruction (Yager, Choi, Yager, et al., 2009). However, students in the study who experienced STS curriculum showed a significant increase in their application of knowledge, creativity, and process skills (Yager, Choi, Yager, et al., 2009). STS practices are closely aligned to CRP. The pool of students who succeed in science coursework lacks in diversity. If, as Yager, Choi, Yager, et al. (2009) note, teachers model what they learn in PD with their students and learning increases, future research should examine how adding CRP to teacher's learning opportunities improves learning across a more diverse pool of students. In this manner, good science teaching in urban classrooms would incorporate a cultural component (CRP) as a conduit to help students learn science.

Furthermore, designers of PD must consider the structure, design, and objectives of teacher in-service, and whether or not practices learned will transfer to the students being served. Policy makers should consider allocating grant money to science teacher PD programs that model CRP alongside content knowledge and pedagogical content knowledge. Perhaps, prior to delivery of a PD program, teacher educators, science faculty, and scientists can meet together to discuss and combine best practices in each field and how it might be brought together for teachers of science. All participants would gain in the knowledge of new perspectives brought out during the discussion. Currently, a

lack of cultural understanding is a barrier to science education for millions of students across the nation. Learning best practice from each other – whether from one ethnic group to another, or from one field and/or level of education to another – exposes unknown viewpoints.

Suggestions for Further Research

As stated earlier, it would be interesting to explore this study with a larger sample of teachers. Indicated in the methodology, SUN and SEPA had six teacher participants each, and CLA had four teacher participants. Differences in the sample size led to use of the Kruskal-Wallis H Test, which does not hold as much power as ANOVA. Additionally, research into programs that run nationally would also be of interest. This study examined two local and one national program. The national program had a larger number of teachers who instructed poor, students of color. Further, the programs studied in this report were regarded highly by participating teachers. Perhaps, by studying more programs that appeal to teachers across the nation, one would gain insight into more varied structures, designs, and objectives and how effective, or ineffective, they are on teacher learning outcomes. Finally, examining how science teacher education programs outside of the United States incorporate CK, PCK, CRP, and CCM into PD would be of interest. Other countries routinely score higher on international assessments when compared to students in the United States. Identifying any similarities or differences between programs in the U.S. and other countries might also benefit all students.

Summary and Conclusions

Teacher learning outcomes were shaped by PD structure, design, and objectives.

SEPA documentation supplied evidence to support teacher learning of CK, PCK, CRP, and some CCM. Participating SEPA teachers evidenced learning of CK, PCK, CRP, and CCM through focus group discussions and evidence of program integration. In comparison, SUN’s documentation supported CK, PCK, and some elements of CRP, and teachers reported gains in CK and PCK. Evidence from CLA supported teacher learning of CK and PCK, and teachers reported gains in CK and PCK through data analysis and online resources. CK and PCK are essential elements of effective teachers, but CRP and CCM must be considered as necessary additions for diverse student populations. PD designers and policy makers must carefully construct and advise teacher professional development so that effective methods are transferred into classroom lessons for all students.

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Appendix A: IRB Exempt Status

UNIVERSITY of WISCONSIN
UWMILWAUKEE

Department of University Safety & Assurances

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New Study - Notice of IRB Exempt Status

Date: January 7, 2014

To: Barbara Bales, PhD
Dept: School of Education

Cc: Amy Zientek

IRB#: 14.205
Title: Elements of effective science teacher professional development to support teacher learning gains

After review of your research protocol by the University of Wisconsin – Milwaukee Institutional Review Board, your protocol has been granted Exempt Status under Categories 1 & 2 as governed by 45 CFR 46.101(b).

This protocol has been approved on January 7, 2014 as exempt for three years and IRB approval will expire on January 6, 2017. If you plan to continue any research related activities (e.g., enrollment of subjects, study interventions, data analysis, etc.) past the expiration date, please respond to the IRB's status request that will be sent by email approximately two weeks before the expiration date. If the study is closed or completed before the IRB expiration date, you may notify the IRB by sending an email to irbinfo@uwm.edu with the study number and the status so we can keep our study records accurate.

Any proposed changes to the protocol must be reviewed by the IRB before implementation, unless the change is specifically necessary to eliminate apparent immediate hazards to the subjects. The principal investigator is responsible for adhering to the policies and guidelines set forth by the UWM IRB, maintaining proper documentation of study records and promptly reporting to the IRB any adverse events which require reporting. The principal investigator is also responsible for ensuring that all study staff receive appropriate training in the ethical guidelines of conducting human subjects research.

As Principal Investigator, it is your responsibility to adhere to UWM and UW System Policies, and any applicable state and federal laws governing activities which are independent of IRB review/approval (e.g., FERPA, Radiation Safety, UWM Data Security, UW System policy on Prizes, Awards and Gifts, state gambling laws, etc.). When conducting research at institutions outside of UWM, be sure to obtain permission and/or approval as required by their policies.

Contact the IRB office if you have any further questions. Thank you for your cooperation and best wishes for a successful project

Respectfully,

Jessica P. Rice
IRB Administrator

Appendix B: Bandura's (2006) Teacher Self-Efficacy Scale – Things that Create Difficulties for Teachers

Questions are adapted from Bandura's (2006) teacher self-efficacy scale that focuses on things that "create difficulties for teachers" (p.328):

1. What grade level do you teach?
2. How long have you been a K-12, science teacher?
3. Do you currently teach at an urban, suburban, or rural school?
4. What course(s) do you currently teach?
5. How often do you participate in science professional development programs?
6. What made you choose to participate in the [SUN, SEPA, CLA] program?
7. What did you expect to gain from the [SUN, SEPA, CLA] program?
8. What surprised you in the [SUN, SEPA, CLA] program?
9. Did participation in [SUN, SEPA, CLA] change your understanding of certain unit(s) in your subject area?

   9b. If you answered "yes" to #9, provide one example of how this influence is seen in practice in your classroom.

10. On a scale of 0 - 100 with 0 = cannot do at all, 50 = moderately can do, and 100 = highly certain can do, are you able to teach the content covered in the summer PD to your students?

    10b. Using the same scale, how confident do you feel the program prepared you to get through to the most difficult students?

    10c. Using the same scale, how confident do you feel the program prepared you to help students learn when there is a lack of support from home?

    10d. Using the same scale, how confident do you feel the program prepared you to keep students on task on difficult assignments?

10e. Using the same scale, how confident do you feel the program prepared you to help increasing students' memory of what they have been taught in previous lessons?

11. Did participation in [SUN, SEPA, CLA] influence how you teach unit(s) in your subject
area?

11a. If you answered "yes" to #11, provide one example of how this influence is seen in practice in your classroom.

11b. On a scale of 0 - 100 with 0 = cannot do at all, 50 = moderately can do, and 100 = highly certain can do, how confident do you feel the program prepared you to motivate students who show low interest in schoolwork?

11c. Using the same scale, how confident do you feel the program prepared you to overcome the influence of adverse community conditions [i.e. community crime, discrimination, harsh parenting, deviant peers] on students' learning?

11d. Using the same scale, how confident do you feel the program prepared you to get children to follow classroom rules?

11e. Using the same scale, how confident do you feel the program prepared you to control disruptive behavior in the classroom?

11f. Using the same scale, how confident do you feel the program prepared you to get children to do their homework?

12. Did participation in [SUN, SEPA, CLA] change the way you teach to a diverse student population?

12a. If you answered "yes" to #12, provide one example of how this influence is seen in practice in your classroom.

12b. On a scale of 0 - 100 with 0 = cannot do at all, 50 = moderately can do, and 100 = highly certain can do, how confident do you feel the program prepared you to successfully teach a diverse student population?

12c. Using the same scale, how confident do you feel the program prepared you to get parents to become involved in school activities?

12d. Using the same scale, how confident do you feel the program prepared you to assist parents in helping their children do well in school?

12e. Using the same scale, confident do you feel the program prepared you to make parents feel comfortable coming to school?

13. Did participation in [SUN, SEPA, CLA] influence your curriculum's connection(s) to the local community?

    13a. If you answered "yes" to #14, provide one example of how this influence is seen in practice in your classroom.
    13b. On a scale of 0-100, with 0 = cannot do at all, 50 = moderately can do, and 100 = highly certain can do, how confident do you feel the program prepared you to make connections between your school's local community and classroom lessons?

    13c. Using the same scale, how confident do you feel the program prepared you to get community groups involved in working with the school?

    13d. Using the same scale, how confident do you feel the program prepared you to get businesses involved in working with the school?

    13e. Using the same scale, how confident do you feel the program prepared you to get local colleges and universities involved in working with the school?

Appendix C: CRP Self-Efficacy Scale

The Culturally Responsive Teaching Self-Efficacy Scale

A number of statements about organizations, people, and teaching are presented below. The purpose is to gather information regarding the actual attitudes of educators concerning these statements. There are no correct or incorrect answers. We are interested only in your frank opinions. Your responses will remain confidential.

INSTRUCTIONS: Please indicate your personal opinion about each statement by circling the appropriate response at the right of each statement.

1=nothing 3=very little 5=some influence 7=quite a bit 9=A great deal

1. I am able to adapt instruction to meet the needs of my students.	1 2 3 4 5 6 7 8 9
2. I am able to obtain information about my students' academic strengths.	1 2 3 4 5 6 7 8 9
3. I am able to determine whether my students like to work alone or in a group.	1 2 3 4 5 6 7 8 9
4. I am able to determine whether my students feel comfortable competing with other students.	1 2 3 4 5 6 7 8 9
5. I am able to identify ways that the school culture (e.g., values, norms, and practices) is different from my students' home culture.	1 2 3 4 5 6 7 8 9
6. I am able to implement strategies to minimize the effects of the mismatch between my students' home culture and the school culture	1 2 3 4 5 6 7 8 9
7. I am able to assess student learning using various types of assessments.	1 2 3 4 5 6 7 8 9
8. I am able to obtain information about my students' home life.	1 2 3 4 5 6 7 8 9
9. I am able to build a sense of trust in my students.	1 2 3 4 5 7 8 9
10. I am able to establish positive home-school relations.	1 2 3 4 5 6 7 8 9
11. I am able to use a variety of teaching methods.	1 2 3 4 5 6 7 8 9
12. I am able to develop a community of learners when my class consists of students from diverse backgrounds and social classes.	1 2 3 4 5 6 7 8 9
13. I am able to use my students' cultural background to help make learning meaningful.	1 2 3 4 5 6 7 8 9
14. I am able to use my students' prior knowledge to help them make sense of new information.	1 2 3 4 5 6 7 8 9
15. I am able to identify how students communicate at home that may differ from the school norms.	1 2 3 4 5 6 7 8 9
16. I am able to obtain information about my students' cultural background.	1 2 3 4 5 6 7 8 9
17. I am able to teach students about their cultures' contributions to science.	1 2 3 4 5 6 7 8 9
18. I am able to greet English Language Learners with a phrase in their native tongue.	1 2 3 4 5 6 7 8 9
19. I am able to design a classroom environment using displays	1 2 3 4 5 6 7 8 9

that reflects a variety of cultures.

20. I am able to develop a personal relationship with my students. 1 2 3 4 5 6 7 8 9
21. I am able to obtain information about my students' academic weaknesses. 1 2 3 4 5 6 7 8 9
22. I am able to praise English Language Learners for their accomplishments using a phrase in their native language. 1 2 3 4 5 6 7 8 9
23. I am able to identify ways that standardized tests may be biased towards linguistically diverse students. 1 2 3 4 5 6 7 8 9
24. I am able to communicate with parents regarding their child's educational program. 1 2 3 4 5 6 7 8 9
25. I am able to structure parent-teacher conferences so that the meeting is not intimidating for parents. 1 2 3 4 5 6 7 8 9
26. I am able to help students to develop positive relationships with their classmates. 1 2 3 4 5 6 7 8 9
27. I am able to revise instructional material to include a better representation of cultural groups. 1 2 3 4 5 6 7 8 9
28. I am able to critically examine the curriculum to determine whether it reinforces negative cultural stereotypes. 1 2 3 4 5 6 7 8 9
29. I am able to design a lesson that shows other cultural groups have made use of mathematics. 1 2 3 4 5 6 7 8 9
30. I am able to model classroom tasks to enhance English Language Learner's understanding of classroom tasks. 1 2 3 4 5 6 7 8 9
31. I am able to communicate with the parents of English Language Learner's regarding their child's achievement. 1 2 3 4 5 6 7 8 9
32. I am able to help students feel like important members of the classroom. 1 2 3 4 5 6 7 8 9
33. I am able to identify ways that standardized tests may be biased towards culturally diverse students. 1 2 3 4 5 6 7 8 9
34. I am able to use a learning preference inventory to gather data about how my students like to learn. 1 2 3 4 5 6 7 8 9
35. I am able to use examples that are familiar to students from diverse cultural backgrounds. 1 2 3 4 5 6 7 8 9
36. I am able to explain new concepts using examples that are taken from my students' everyday lives. 1 2 3 4 5 6 7 8 9
37. I am able to obtain information regarding my students' academic interests. 1 2 3 4 5 6 7 8 9

38. I am able to use the interests of my students to make learning meaningful for them.	1 2 3 4 5 6 7 8 9
39. I am able to implement cooperative learning activities for those students who like to work in groups.	1 2 3 4 5 6 7 8 9
40. I am able to design instruction that matches my students' development needs.	1 2 3 4 5 6 7 8 9

From: Coston (2010)

Appendix D: Teacher Evidence of Content Knowledge

Honors Biology Name______________________
Questions about Cellular Respiration…

1. Glucose is the ultimate electron donor…

   Which atom in glucose carries and donates the electrons?
   ____

2. Which atom is the electron acceptor? __________________

3. Which molecule carries TWO electrons and TWO protons (hydrogen) from one pump to another?

   (pink quinone or blue cytochrome C)

4. Which molecule carries ONE electron at a time from one pump to another?

   (pink quinone or blue cytochrome C)

5. What is the 'work' being done by electrons as they move from one pump to another? ___________________________________

6. How many protons (hydrogen) get pumped into the *intermembrane space* once the electrons pass through all three proton pumps? ________

7. What structure takes protons (hydrogen) from the inter-membrane space and returns them to the matrix?
   ____

8. In ATP Synthase every ____ protons causes ATP Synthase to produce 1 molecule of ATP.

9. What does ATP provide for the cell organelles? ____________

Appendix E: Teacher Evidence of Pedagogical Content Knowledge

Evidence of ***SUN Project*** Program Integration

CAPP Biology Course – Cellular Respiration

My CAPP (College Advanced Placement Program) Biology was driven by reflective practices. Early in the year students were introduced to the Hydrogen Fuel Cell Activity with this reflective query:

> Given the fact that the flow of electrons does work in both the fuel cell as well as living systems, write a comparative reflection on your experience in this lab activity. Relate flow of electrons to work in the fuel cell - powered motor and to the flow of electrons in your body to generate ATP.
>
> Rubric: Well developed, word processed paper relating the flow of electrons in the fuel cell as well as living systems. Double spaced between 200 and 300 words. Be prepared to supply an electronic copy if requested.

Cellular Respiration was introduced by re-visiting the Hydrogen Fuel Cell Activity. The purpose was to establish the concept that the flow of electrons does work. This concept would then be expanded from the abiotic world of the hydrogen fuel cell to the biotic world of cellular respiration – an essential life process. To follow is the reflective query:
Revisit your original Fuel Cell Reflection which addressed the following:

> Given the fact that the flow of electrons does work in both the fuel cell - powered motor as well as living systems, write a comparative reflection on your experience in this lab activity. Relate flow of electrons to work in the fuel cell - powered motor and to the flow of electrons in your body to generate ATP.
>
> As we progress through Cellular Respiration continue to make parallels. Re-write your reflection. Turn in both your original and new reflection. Include a paragraph that reflects your learning curve. This reflection will be due on the day of test.
>
> **Rubric:** Well developed, word processed paper discussing the above queries and follow-up. Double spaced between 200 and 300 words. Be sure to develop your answer to demonstrate your understanding of the queries. Be prepared to supply an electronic copy upon request. If you are absent on due date, send an electronic copy via e-mail.

Cell mats are then introduced with associated vocabulary placards. Students are asked to use the vocabulary placards to orientate themselves to the cellular structures, functions, as well as the major inputs and outputs of cellular respiration and photosynthesis. (Note: Cell mats were first introduced in the unit on cell structure and function.)

> A formative assessment is accomplished via oral questions asked by the teacher to the various student groups. Misconceptions are addressed on an individual group basis.

Self-guided SMART Notebook tutorials are used to guide students through the ten steps of Glycolysis. Students work with a partner and save their SMART Notebook along with their analysis and conclusion remarks to the school's G-drive for teacher review and comment.

Similarly a self-guided SMART Notebook tutorial is used to guide students through major reactions of the Citric Acid Cycle. Again students work with a partner and save their SMART Notebook along with their analysis and conclusion remarks to the school's G-drive for teacher review and comment.

Students are then introduced to the SUN Project water molecule, the laminated mitochondrial membrane, various protein complexes, mobile carriers and electron donors to aid in the understanding of what happens in the Electron Transport Chain. This is accomplished during a SMART Notebook presentation by the teacher where the flow of electrons through the mitochondrial membrane is demonstrated. Students are then given the laminated table-top models to manipulate the process and the attached activity entitled Laminated ETS Activity. This is an ungraded activity.

Students are then introduced to the SUN Project Tray Models and manipulatives. They use the pdf developed by Dr. Batiza for the SUN Project entitled CR-Path of Electrons Worksheet.

Using *Campbell* 9e, students manipulate the ATP Synthase model to generate ATP.

A selection of short answer essay questions that have been given to students at the beginning of the Cellular Respiration Unit are used as the unit assessment tool and are scored using a rubric. I can make a sample of these questions and the scoring rubric available as requested.

Appendix F: Teacher Evidence of Culturally Responsive Practices

Lead Project - Summary, Directions and Rubric

This project will conclude our studies of sustainability, ecology and human impact on the environment, and serve as our Semester One Final Assessment. Project presentation dates will be determined during the planning process.

Summary of Project:

Driving Question:
How can we, as high school students, design a solution to reduce the impacts of lead on the environment, humans, and other organisms that can be by consumed by the general public?

Project Description:
Students will work to design a solution to design, evaluate, and refine a solution for reducing the impacts of lead on the environment, humans, and other organisms. They will identify a specific issue surrounding lead that they wish to address, learn about this issue, and then write a short proposal of their solution. After this is approved, they will create a product - this might either BE the solution, or it might describe a solution that they think should be used.

Students will present their solutions to their peers and to a small group of school or community members, such as scientists, public health officials, etc. If they create an item of art or a video they may submit to UWM for consideration for an award.

Project Purpose:
The purpose of this project is to give students the opportunity to apply their understanding of how the specific human impact of lead is similar to the ways in which other human impacts develop into global problems. We also want to give students the opportunity to be creative, collaborative, and to practice problem-solving and questioning skills.

Steps to Completing the Project

Step 1 - **Identify the Issue** - identify the specific issue with lead that you want to address with your project. (Examples might include: how children take in lead; lack of funding for lead research; clean up lead near factories). (formative check)

Step 2 - **Project Proposal** – write a short proposal for their solution. It should include the specific issue you are addressing, how you are addressing it, and how and why you think it will reduce the impacts of lead. It will also include a list of any materials that you will need, and where you plan to get those materials.
(formative - check off)

Step 3 - **Work on Project** - you will be observed for evidence of inquiry and problem-solving skills as you work. (summatively - inquiry target)

Step 4 - **Present -** present your solutions to your peers and to a small group of school or community members.

Step 5 - **Evaluate -** assess yourself and your group members on your learning and inquiry skills.

Project Proposal Checklist

When completed, submit to your instructor for **approval before you begin.** Your team will then meet with your instructor to review your proposal, make adjustments as needed and to answer any questions.

[ ] What is the issue that you wish to address with your project?
[ ] How are you addressing this issue?
[ ] How and why do you think your work will reduce the impacts of lead?
[ ] What materials will you need and where do you plan to get these materials?

Rubrics for Product

This project will be used to assess one of the Next Generation Science Standards "Performance Tasks" as described below:

"Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity." (HS-LS2-7)

The following rubrics will be used to assess this Performance Task, which includes two of our Learning Targets - #1 (Inquiry) and #7 Concepts and Content:

Learning Target 1 - I can solve problems using inquiry and critical thinking.	Incomplete I cannot solve a problem using inquiry and / or critical thinking.	1 – Minimal I can solve a problem using inquiry and / or critical thinking.	2 - Basic I can solve a problem and provide clear evidence of the process.	3 – Proficient I can solve a problem and provide clear and complete evidence of the process, while taking into account the complexities of the problem while also identifying the limits of my proposed solution.	4 - Advanced I can justify my solution by explaining how my concepts and strategies are effective and reasonable, and support those strategies with evidence that moves beyond the obvious.

Learning Target 7 - Students will communicate information about science concepts, core ideas and crosscutting themes.	Incomplete I can not summarize a specific human impact on the environment or biodiversity.	1 - Minimal [ ] I can summarize a specific human impact on the environment or biodiversity.	2 (1+) – Basic [ ] I can describe the specific ways in which a human impact on the environment or biodiversity affects organisms and/or ecosystems (such as health, population size, etc.)	3 (2+) – Proficient [ ] I can describe the various factor(s), such as biological, economic, and social, that contribute to the perpetuation of a human impact on the environment or biodiversity.	4 (3+) – Advanced [ ] I can justify why my solution to address a specific human impact is logical and appropriate by providing evidence of the specific biological, economic, and social ways it would improve the problem.

Note for Students Who Wish to Submit a Work of Art or Video to UW-Milwaukee

Visual arts can provide an important and creative tool for conveying a scientific message. As a special feature of the SEPA program we are involved in, UWM is hosting an art and video contest open to any current student in the program. The awards, given at an April conference, are nice, and you have a chance to reach a large audience with your message. You are not required to submit your work to UWM, but we encourage you to consider it! **Complete guidelines from UWM are posted on Blackboard.**

If your group is not interested in creating an item that could be submitted to UWM, you may choose to create an entry independently or with a group outside of this project. If done outside of this project, the toxin you focus on can be lead, alcohol, caffeine, or nicotine. **All entries for UWM must be submitted to the proper person by Friday, March 7, 2014.** See Ms. Corado with any questions regarding the UWM program.

Appendix G: Teacher Evidence of Conceptual Change Model

Name ______________________ Hour_____

Learning Target 5 - Students will perform scientific investigations to evaluate relationships and draw conclusions.

4	3	2	1	0
I can assess the validity of my conclusion and support my assessment with evidence that moves beyond the obvious.	I can assess the validity of my conclusion and support my assessment with evidence.	I can form an accurate conclusion supported by evidence when presented with scientific information.	I can form a simple conclusion when presented with scientific information.	I cannot form a conclusion when presented with scientific information.

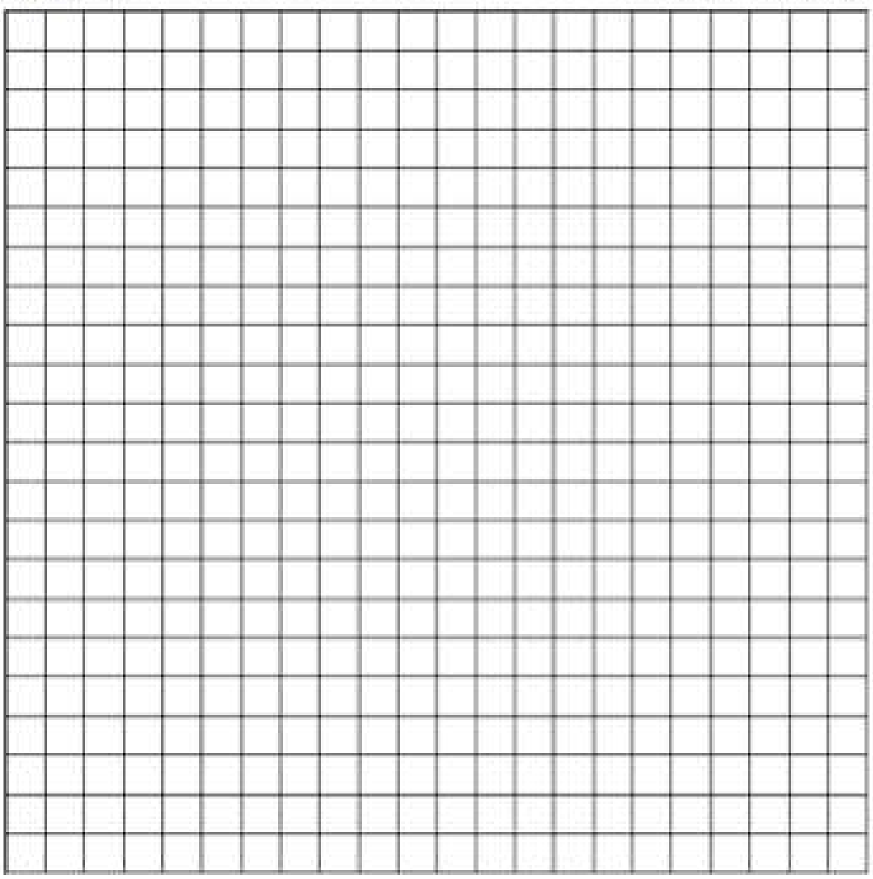
Impact of ___________________________________ (independent variable) on

____ (dependent variable)

of ____ (test subjects)

Results

Figure 1: ____ (dependent variable as defined on the graph) Certain Behaviors Were Performed by ______________________________________ (test subjects) in ____ (independent variable)



Component of Results Section	Your Writing
Two intro sentences - explain reasons for doing the experiment.	
Restate hypothesis.	
Describe experiment (identify the independent and dependent variables, and controls).	
Describe the results.	
Connect the results to the point of the experiment: Did they support the initial hypothesis? Did they provide the information you were looking for? Were there problems in the experiment that compromised the results?	

Discussion

Component of the Discussion Section	Your Writing
Summarize the most significant results (1-2 sentences).	
Discuss connections, patterns, trends in the data	
Link the experiments with the knowledge that you gained about lead before doing the experiments. What does the research results mean? What is the relevance? (Who should care, and why?)	

Self-Reflection

1. How did you do at keeping accurate, organized records during the experiment? Explain.

2. How did you do at concentrating during your minnow observations? Explain.

3. How did you do at collaborating and cooperating with the people in your group? Explain.

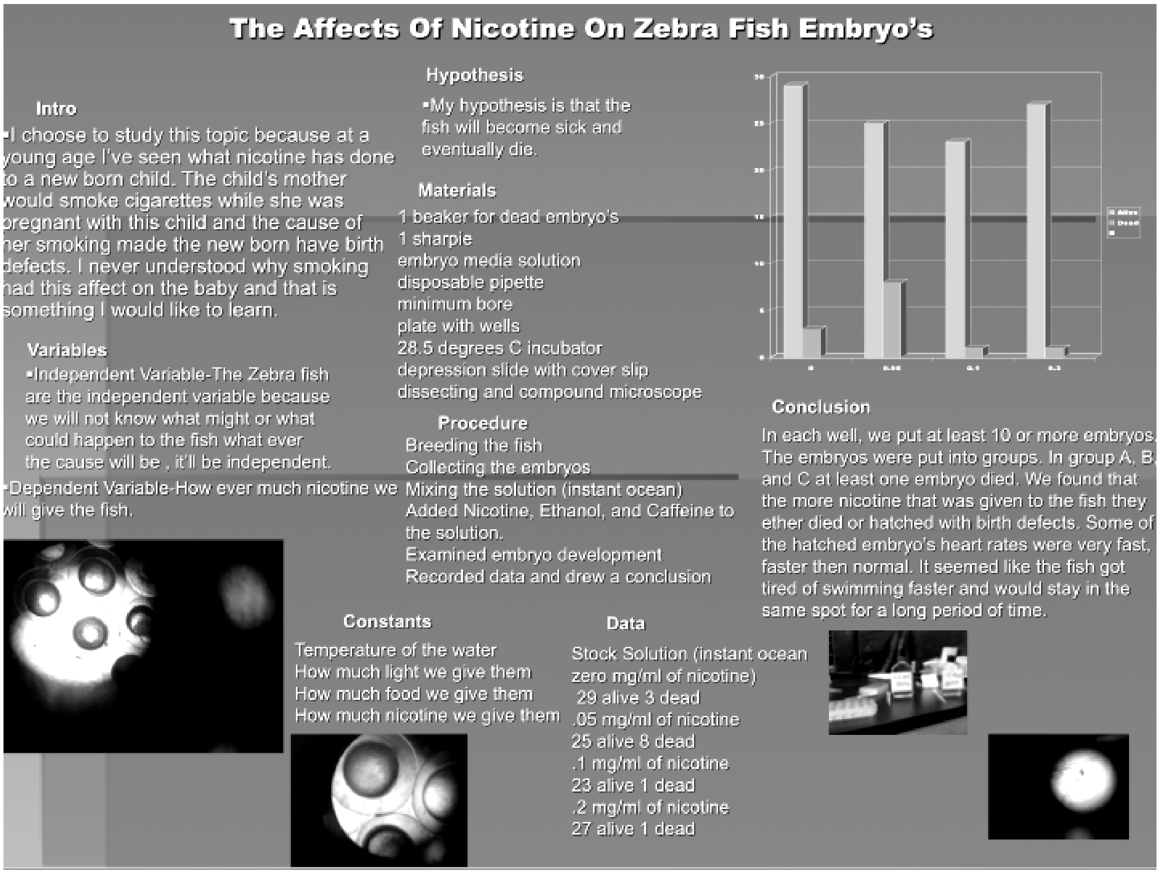
4. How did you do at creating an accurate, easy-to-read and understand graph?

5. How did you do at analyzing and discussing your results? Explain.

6. What will you do differently next time we do an experiment?

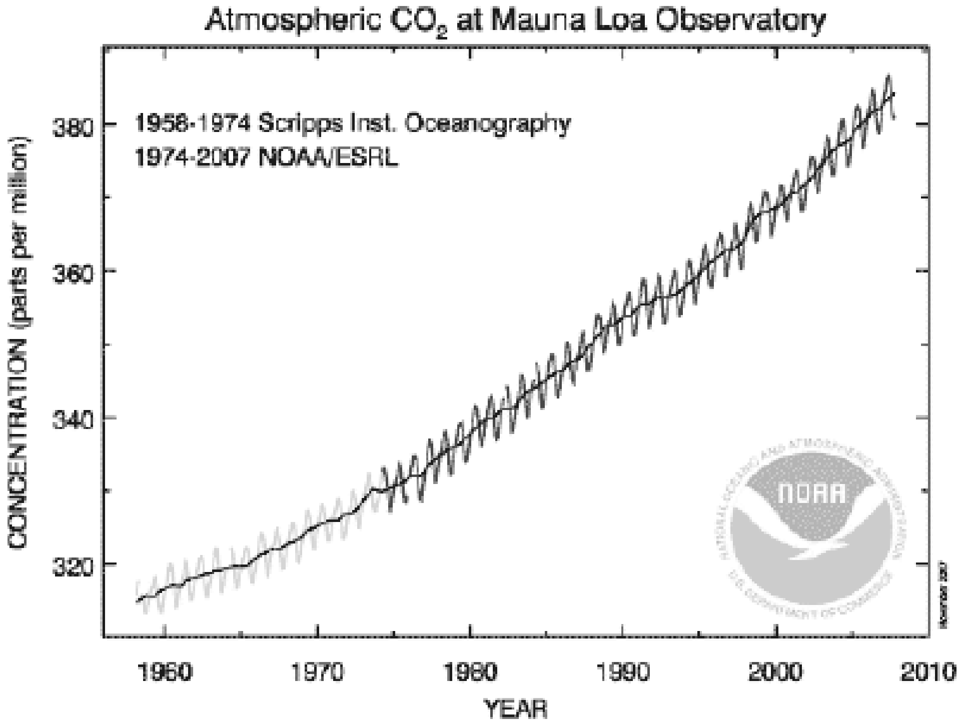
7. What most interests you, surprises you, concerns you, or saddens you about lead poisoning?

Appendix H: Teacher Evidence – Example of Student Work



Appendix I: Teacher Evidence of Data Analysis

Modeling the Keeling Curve with Excel



This is the Keeling Curve, derived by researchers at the Mauna Kea observatory from atmospheric carbon dioxide measurements made between 1958 - 2005. The accompanying data in Excel spreadsheet form for the period between 1982 and 2008 is provided at

http://spacemath.gsfc.nasa.gov/data/KeelingData.xls

Problem 1 - Based on the tabulated data, create a single mathematical model that accounts for, both the periodic seasonal changes, and the long-term trend.

Problem 2 - Convert your function, which describes the carbon dioxide volume concentration in parts per million (ppm), into an equivalent function that predicts the mass of atmospheric carbon dioxide if 383 ppm (by volume) of carbon dioxide corresponds to 3,000 gigatons.

Problem 3 - What would you predict as the carbon dioxide concentration (ppm) and mass for the years: A) 2020? B)2050, C)2100?

CURRICULUM VITAE

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PROFESSIONAL INTERESTS:

My professional interests aim to improve the quality of science instruction at the K12 level. These improvements involve modification to science teacher professional development with the goal of integrating methods that will transfer into classroom practice and impact all students. Science teacher professional development has been shown to center on the development of content knowledge and pedagogical content knowledge. Studying how culturally responsive practices impact student learning, as well as how such practices can be incorporated into science teacher professional development may add another essential element for designers of PD.

EDUCATION:

Master of Science – Curriculum and Instruction (2007)
University of Wisconsin – Milwaukee
Bachelor of Science – Biology Major, Chemistry Minor with Honors (2003)
University of Wisconsin – Milwaukee

WISCONSIN TEACHER CERTIFICATIONS (Grades 6-12):

1605 Biology/Life Science
1610 Chemistry
1601 Broad Field Science

PROFESSIONAL EXPERIENCES:

Instructor – University of Wisconsin – Milwaukee (2012)
Summer Pedagogy Lab in Environmental Science

Teacher – Greendale High School (2012-Present)
Advanced Placement Biology (2012-Present)
Honors Biology (2012-Present)
Integrated Life Science (2013-2014)

Teacher – Union Grove High School (2006-2012)
Advanced Placement Biology (2006-2012)
Biology (2006-2012)
Life Science (2010-2012)
Anatomy & Physiology (2011-2012)
Teacher – South Milwaukee High School (2005-2006)
Physical Science (2005-2006)

Biology (2005-2006)

Advisor – Union Grove High School (2010-2012)
Science Club

Participant & Presenter – Milwaukee School of Engineering (2009-2011; 2013-Present)
Teacher's FIRST Program (2013-Present)
Students Understanding eNergy Program (2009-2011)

Participant & Presenter – Medical College of Wisconsin (2012-2013)
Frontiers in Physiology Program

Participant – University of Wisconsin – Madison (2012)
Fast Plants sc Workshop
Advanced Placement Biology Workshop

Participant & Presenter – University of Wisconsin –Milwaukee (2010-Present)
Science Education Partnership Award Program

Participant & Presenter – Gateway Technical College (2009-2010)
Teacher Externship

Participant & Presenter – University of Wisconsin – Whitewater (2008-2009)
Science Education & Leadership Program

Participant – University of Loyola – Illinois (2006)
Advanced Placement Biology Workshop

Presenter – Wisconsin Society of Science Teachers Convention (2013)
Wausau, WI

SERVICE AND OUTREACH:

Advisor – University of Wisconsin – Milwaukee (2013)
MACSTEP Advisory Meeting

Professional Learning Coordinator – Milwaukee School of Engineering (2014-2015)
Institute of Education Sciences: Energy Across Disciplines

PROFESSIONAL AFFILIATIONS:

Wisconsin Society of Science Teachers (WSST)
National Science Teachers Association (NSTA)
University of Wisconsin – Milwaukee Honor Program

AWARDS:

Donald P. Timm Scholarship (2013-2014)
Chancellor's Graduate Student Award (2012-2013)
2013 DonorsChoose.org Grant ($900)
2012 Frontiers in Physiology Mini-Grant Award for RTs ($300)
2010 Outstanding Science Teacher – University of Minnesota, Twin Cities