INTEGRATION OF CULTURALLY RELEVANT PEDAGOGY INTO THE SCIENCE LEARNING PROGRESSION FRAMEWORK

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ABSTRACT

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This study integrated elements of culturally relevant pedagogy into a science learning progression framework, with the goal of enhancing teachers’ cultural knowledge and thereby creating better teaching practices in an urban public high school science classroom. The study was conducted using teachers, an administrator, a science coach, and students involved in science courses in public high school. Through a qualitative intrinsic case study, data were collected and analyzed using traditional methods. Data from primary participants (educators) were analyzed through identification of big ideas, open coding, and themes. Through this process, patterns and emergent ideas were reported. Outcomes of this study demonstrated that educators lack knowledge about research-based academic frameworks and multicultural education strategies, but benefit through institutionally-based professional development. Students from diverse cultures responded positively to culturally-based instruction. Their progress was further manifested in better communication and discourse with their teacher and peers, and increased academic outcomes. This study has postulated and provided an exemplar for science teachers to expand and improve multicultural knowledge, ultimately transferring these skills to their pedagogical practice.
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Dedication

To my loving husband, Travis. Thank you for helping me through this exciting and challenging journey. I cherish your support and encouragement above all.

To my mother, Naza. You are and always will be my source of strength, and the one I turn to for advice. Thank you for being an angel in my life.
CHAPTER ONE
INTRODUCTION

With eight years spent as a New York City public high school teacher, I have gained much experience with students, teachers, and administrators in an economically disadvantaged, diverse school. The connections I have made with my students over the years have brought passion to my life, as well as a strong desire to improve the education of at-risk children. According to the New York City Department of Education (2013), the student body of the public school in the Bronx is predominantly Hispanic (63%) and African American/Black (34%), populations often burdened by chronic poverty and high drop-out rates. In addition, English Language Learners (ELLs) and Special Education students comprise a substantial portion (30% and 20%) of the student population. While the dropout rates for Hispanic and Latino high school students have dropped, the numbers are still significantly higher than those of their White counterparts (Fry, 2003). US Census data (2012) also shows that by the year 2043, the nation will be described as majority-minority, and all minority groups together are predicted to make up about 57% of the total population by the year 2060. As I have gained new insight into the circuitous world of public education in this great city, I realize that nondominant students are not being offered the same opportunities and resources that are available to public schools in more economically advantaged localities. According to Walters (2001), “access to public education is a social good” (p.37) suggesting availability of equal resources for all social classes is vital for societal progress. While I believe this is partly due to political malfeasance, another major contributing factor is a lack of communication between educations and students.

The communication failure is not necessarily intentional, but occurs because educators lack the knowledge and the skills required to create effective bonds with students coming from
multicultural backgrounds. This problem extends into the science classroom, where science teachers are expected to facilitate the learning of complex scientific concepts and terminology but are unaware of how to proceed when students speak a different language or suffer from a disability. Lee (2001) states that while science educators must teach Western science to all students, they must also be aware of differences in meanings, definitions, symbolisms, and practices from other cultures; otherwise, they risk diminishing the overall quality of the educational experience. Thus, in order to achieve equitable instruction for all students, each must be allowed to express their linguistic and cultural identities while making connections to the immediate environment. It is also vital for students in the United States to be scientifically literate as the most recent data from the Program for International Student Assessment (PISA) ranks American fifteen year olds near the bottom of the list in scientific literacy (PISA, 2012).

It is my hope that teaching institutions will extrapolate from the research data to create professional development (PD) programs for in-service professionals that train educators on becoming multicultural while using academic frameworks, especially in the science classroom. In chapter two’s literature review, I address the conceptual framework of learning progressions specific to science and biology, speak about multicultural education in the classroom, and address how professional development can ameliorate deficiencies in teacher knowledge.

Rationale for Research

Ongoing evolution of educational needs

For one to think of education without thinking about culture would be counterintuitive. Education, as it has been recorded and studied throughout history, has afforded individuals the opportunities to make a meaningful impact on life, regardless of status in society.
An influential figure surrounding ideas of power and education was Antonio Gramsci, best known for his theory of cultural hegemony, describing how capitalist States use cultural institutions to maintain power. For Gramsci, hegemony meant leadership, both moral and intellectual in nature, of one group in society over a subordinate group. Education’s purpose was to develop working class individuals who could maintain and improve existing intellectual beliefs. Gramsci believed that all individuals had the capacity for acquiring knowledge and constructing new knowledge. He also believed that students should learn science as a means of dispelling misconceptions about the world, and they must learn how to be proper citizens through civic duties. Students would also learn the differences between natural laws of the world, which cannot be tampered with by man and state laws, which are fluid and can be manipulated as necessary (Gramsci, 1971). Gramsci’s writings are significant in the educational community for addressing the importance of providing equal educational opportunities for all individuals, regardless of social status.

How can one describe an educated individual or subject? Fendler (1999) attempts to analyze how the educated person has been socially constructed throughout history, beginning in ancient Greece with Plato. The Greek Philosopher’s description of an educated subject was one who attempted to cultivate their true nature and was aligned to reason and the aesthetics. In the thirteenth century, with the advent of science, the educated individual had working knowledge of the sciences and theology. In a somewhat contradictory paradigm to modern beliefs, to be educated in medieval times meant reconciling religious doctrines and theology with scientific reasoning, experimentation, logic, reasoning, and empirical evidence. During the seventeenth century, the philosopher Descartes began discourses on the idea of “cognition” as being an important element of the educated subject. He postulated that a person’s thought processes are
abstracted from the body but not separated. His construction of rationality assumed that an educated subject possessed a rational identity, while using methodological experimentation and empirical elements to discover truths.

Immanuel Kant, in the eighteenth century shifted the idea of the educated self as being both the investigator and the investigated. His writings held great significance in the evolution of education and the educated subject as now, the focus changed from the subject to the object. Instead of an individual using intangible explanations and imperceptible reasoning to explain phenomena, demonstrated, empirical evidence was now necessary and became widely accepted as valid and reliable. Importantly, we see a shift from subjective knowledge focused on the individual as educated to objective knowledge focused on society as the basis for justifying the educated subject’s capacities. Social contexts, not individual ones became the standard by which to describe and resolve questions, ideas, and issues. Arguments regarding race and gender began to take form and the problem of diversity in society had to be addressed. These were all ideas identified in history was the period of modernity (Fendler, 1999).

With the advent of technology came the need for disciplines such as statistics and psychology. With such major advances being made in the realm of the human population, new problems began to take shape in the form of social and political issues. Psychology became the new benchmark used to identify and describe the educated subject. Statistics such as correlation and probability was used to verify social events. Psychological normalcy was the desire of all individuals because to be normal, meant being able to control one’s knowledge, and by extension, to possess power. It is here that we see a major paradigm shift from the idea of power as being separated from the self in the past to the idea of power as being self-regulated by each individual (Fendler, 1999).
Towards the end of the nineteenth century and the beginning of the twentieth century, many educational reformers such as Horace Mann and Jane Addams were influential in establishing the Common Schools, the New York City Public Schools. While the system eventually failed in its goals of promoting democracy, equality, and efficiency, this reformation laid the foundations for the American school system. Though far from perfect, getting an education did provide a means for people coming from all socio-economic backgrounds to be financially successful and independent. The availability of education also saw a rise in economic success for the country as a whole (Nasaw, 1979).

Educators in today’s classrooms are now being asked to recognize that for students to become educated subjects, academics and discipline are not enough. Additionally, students must feel encouraged, motivated, and have an urgent desire to learn. Thus, theoretical frameworks such as constructivism seeks to use social interactions of students and teachers to construct new knowledge using prior formulations as guides and making connections to create interest for concepts being taught. For social mobility, students with good communication skills, and abilities to work in cross-functional teams with flexibility are the ones who are exceptional candidates for employment, especially in high-wage white-collar employment (Fendler, 1999).

To further address why modern science educators must consider using academic formulations of instructional frameworks combined with the tenets of multicultural frameworks, an examination of learning theory is warranted to show that modern students from diverse cultures will increase motivation when topics are relatable. Glaser and Bassok (1989) detailed a psychological cognition approach to learning, which outlines strategies of acquiring skills, comprehension, and knowledge as integral parts of learning. The authors discuss how important it is for individuals to acquire and become proficient in certain skills but also stress that unless
these new skills are applied to relevant, familiar situations, depth of understanding at a cognitive level will not occur. Practicing said skills or proceduralization encourages cognitive changes and results in successful use and practice of learned knowledge. How do students become cognitively interested in their own learning? One idea presented by the authors is that students experience conceptual change through their own intrinsic motivation and interest to acquire understanding of their surroundings. When presented with fundamental knowledge, students will attempt to create explanations for events, sometimes failing in these endeavors. This struggle directs them to initiate mental experimentation (Gelman & Brown, 1986), and proceed to inquiry-driven testing.

Another important consideration of learning is the idea of internalization, which has been discussed by both Piaget (1926) and Vygotsky (1978) as being a significant cognitive event occurring in social settings. Vygotsky’s zone of proximal development is an important construct for students to practice learning through prolonged struggle. Here teachers provide guidance through scaffolding and activities supportive of students’ competency levels and students access higher performance levels (Vygotsky, 1978).

Instructionally, Glaser and Bassok (1989) discuss the role of the teacher in the learning process. They describe an approach where a sequence of instruction follows a progressive path of building skills, which are then utilized in appropriate tasks. Another role allows the learner to construct his or her own paths through careful guidance from the teacher. The common thread in both stances described is the need for a strong relationship to exist between the teacher and learner(s). Human performance encompasses problem-solving skills, cognitive skills, and metaconceptual strategies. To become a highly effective teacher/instructor, knowledge of how your students learn based on culture is vital. This knowledge is the buy-in that teachers need
when they encounter diverse student populations. The initial establishment of trust will pave the way for learning and creating conceptual knowledge through education.

Science learning progressions and culturally relevant pedagogy are two major frameworks used in education. SLPs has been defined by Duncan and Rivet (2013) as, “research-based cognitive models of how learning of scientific concepts and practices unfolds over time” (p.396). The learning progression is a newly proposed set of ideas, having only been proposed in 2005 by the National Research Council. By contrast, the multicultural framework of CRP was made popular by Gloria Ladson-Billings in the early 1990s and in her paper, towards a theory of culturally relevant pedagogy from 1995, expressing the importance of using a student’s cultural norms in his or her educational experiences.

Both frameworks address important yet distinct aspects of education. Yet to date, the literature presents no attempts to merge these two divergent frameworks into an elegant set of ideas that can be applied to the urban public school curriculum. It is well known and well documented that many students attending public schools in the United States come from different cultural and linguistic backgrounds. Howard (2003) mentioned that about one-third of all students in U.S. schools were minorities, and by the year 2050, that percentage would increase to approximately fifty-seven percent. It is because of a growing culturally-diverse student population that there is an urgent need for multiculturally-trained science teachers. This study will address an initial attempt at creating an instructional tool that incorporates these differing ideas.

Pilot study

A pilot study that I conducted (See chapter three and Appendix A) in the Fall of 2013 as part of the requirement for completing a science education course highlights the need for a
unified conceptual framework that combines principles of both science LPs and culturally relevant pedagogy. In the study, I interviewed three high school science teachers on their knowledge of science LPs and multicultural education, and how knowledge of students’ cultures might enhance students’ engagement and learning in the classroom. The findings described the deficiencies faced by experienced science and new science teachers with respect to the two theoretical frameworks. However, the majority of teachers interviewed agreed that it is beneficial to be knowledgeable in diverse cultures to help build student-teacher relationships, which are vital for motivating students in the classroom. Notwithstanding the fact that these are not the only two theoretical or conceptual frameworks on the educational spectrum, but when faced with problems surrounding student culture and poor test results from students of color, it makes sense that leaders and administrators would search for a resolution that addresses how to encourage diverse students to learn.

**Focus of research**

With new standards being introduced into schools across the nation, it is imperative for schools to adapt curricula, while ensuring equity for all students. Although some science teachers, such as my pilot study participants are currently unfamiliar about the use of new techniques to enhance their pedagogical skills, there are steps to be taken to solve this problem. I argue that the creation of targeted professional development opportunities either in-house or through outside consultants focused on science LPs and multicultural education will provide the knowledge and training that is required by teachers for successful outcomes in urban public high schools. Addressing educational institutions that provide teacher-preparation programs requires more research and expertise into the policies that control these organizations. However, much change is necessary in order to re-shape the ideas of how to teach children.
This dissertation study focused on teacher-student interactions in multicultural science classrooms where the teacher participant was asked to implement a science LP specifically designed with multicultural elements for that classroom as well as teacher-student interactions in a classroom utilizing teaching methods with no interventions. The teacher participant was required to use inquiry-based pedagogical techniques in the implementation of lessons, such as introducing a big idea and an essential question for a unit, which was constantly referred to during the unit being taught. My findings are described using constructivist theory ((Piaget, 1926; Vygotsky, 1978) to interpret my data since the guiding principles behind constructivism focuses on people learning through constructing meaning from prior experiences and knowledge, as well as through stimuli from the surrounding environment. As can be seen in figure 1.1, science LPs, CRP, and inquiry approaches can all be linked as effective pedagogy in classrooms as having overlapping elements. I argue that through observations and analyses of data collected in this study, specific deficiencies can be identified, addressed, and resolved; giving science teachers the knowledge, skills, and techniques to be successful in diverse classrooms, while allowing students from different cultures to feel welcome. This will create an environment where students are interested and engaged in learning science.
An important question that arose during the development of this study was how can stakeholders in education consider all aspects of students when creating frameworks for practitioners to apply to their classrooms, and making these guides fully accessible to practitioners? According to Ching (2013), it can be difficult for teachers to link the theory that is learned in teacher preparation programs and training workshops to actual practice in classrooms.

Figure 1.1: Progression of Science Learning Integrated with Multiculturalism (PSLIM). This figure links aspects of Science Learning Progressions (NRC, 2005) and Culturally Relevant Pedagogy (Ladson-Billings, 1995). By combining SLP and CRP principles, it is possible to inform pedagogy that follows relevant links to science and engineering practices that meets the standards for socially constructed, transformative learning.
However, it is necessary to ensure a relationship exists between theoretical concepts and the practical nature of pedagogy (Shulman, 1992). The focus of this study therefore provides a novel attempt to combine traditionally divergent frameworks by introducing formal elements of a multicultural framework (CRP) into an instructional framework (SLP) and providing directed training for a teacher to immediately implement in the classroom.

The assembling of these two sets of principles does not currently exist in the literature thus my study represents an example of how to align prominent ideas that are perceived as being disparate, but not necessarily conflicting. It seems almost obvious that when in-service teachers practice in diverse school populations where they encounter unfamiliar cultural and linguistic practices, they should be trained not only in instructional strategies and methods, but also in culturally appropriate ways to approach students from diverse cultures. Through personal experiences and from interview responses with other educators, it has been determined much of the professional development they experience focuses mainly on pedagogical techniques and standards rather than multicultural training. Hence, this study serves to fill a gap in the literature that has not yet been addressed.
Research Questions

1. How knowledgeable are educators about the use and implementation of Science Learning Progressions and Multicultural Education methods?

2. How through professional development do we integrate Culturally Relevant Pedagogy with parts of a Science Learning Progression for teacher learning?

3. What does the use of a science learning progression integrated with elements of culturally relevant pedagogy look like in a science classroom?

The above questions are based on an ongoing need for science teachers to be fully knowledgeable regarding their content specialties and their students. It is urgent for current school officials to reflect on current literature regarding methods for success in science, student learning abilities, teacher-student relationships, multiculturalism, and relevant PD workshops.

In the next chapter, I will discuss the literature that has informed my research study. I will present principles of Science Learning Progressions and Culturally Relevant Pedagogy as well as Constructivist theory, which will be used as an analysis tool. Other classroom considerations will be presented including the establishment of routines and rituals to create a positive environment for all students and how professional development will inspire teacher practices.
CHAPTER TWO
THEORETICAL FRAMEWORKS AND LITERATURE REVIEW

Theoretical Frameworks

Learning Progressions in Science Education. For several decades, policy-makers, researchers, and educators have been proposing new ideas, frameworks, and models to improve science education in the United States. Reforms in standards, curriculum, and assessments are needed to improve both pedagogy and student learning in science in the nation’s public schools. In New York State, the current curriculum standards consist of key ideas and performance indicators that are a mile wide, and an inch deep (University of the State of New York, 1999). Reforms are necessary to rein in these numerous, shallow concepts into a few core ideas that can serve as the main focus of instruction, where students can develop rich, deep understanding and be able to analyze, predict, and create based on their knowledge (Corcoran, Mosher, & Rogat, 2009). Reforms of current science standards are driven by students becoming more sophisticated when understanding concepts, practicing science, and science epistemology (Duncan & Rivet, 2013).

The learning progression (LP) is a relatively new framework designed to help students gain success in school and become informed critical thinkers. The term ‘learning progression’ was first coined in 2005 by the National Research Council in the publication Systems for state science assessments. The concept of a LP has been given several somewhat similar definitions. It has been described as “a carefully sequenced set of building blocks that students must master en route to mastering a more distant curricular aim (Popham, 2007, p.83), and “a theoretical model of how learners develop expertise in a domain over extended periods of time” (Shea & Duncan, 2013, p.7). The National Research Council (2005) describes LPs as “descriptions of the
successively more sophisticated ways of thinking about an idea that follow one another as students learn” (p.48) while Nichols (2010) defines LP as a way of using words and examples to achieve expert understanding over a period.

Science LPs are slightly different in designation. Science LPs have been developed as a method to improve the cognitive and learning skills in children, with the hope of achieving competence and mastery in the science disciplines (NRC, 2005). A science LP is guided by research data that is used to inform the overall sequence of the proposed model. The framework can be defined as “empirically-grounded and testable hypotheses about how students’ understanding of, and ability to use, core scientific concepts and explanations and related scientific practices grow and become more sophisticated over time, with appropriate instruction” (Corcoran, Mosher, & Rogat, 2009, p.15). Duncan and Rivet (2013) define science LPs as “research-based cognitive models of how learning of scientific concepts and practices unfolds over time” (p.396). These definitions point to a theoretical framework that, when used correctly, allows students to participate in constructive learning, using inquiry-based models and practicing/improving critical-thinking skills. For this study, the SLP unit used builds upon initial simple concepts, getting progressively more complex and utilizing different modes to allow students to learn about different topics.

According to Duschl, Maeng, and Sezen (2011), designing a learning progression on a topic that has been well researched can be initiated by using existing literature that describes how students learn the concept(s) best and can be designed in a theory-driven manner. For example, Duncan, Rogat, and Mosher (2009) developed a science LP to help 5th through 10th grade students understand genetic concepts. Although their proposed model was conjectural and not empirically grounded, it suggested that LPs consisting of a few core ideas taught at a deep level
will produce improved understanding and construction of knowledge in students.

Furtak, Morrison, Iverson, Ross, & Heredia (2011) designed a science learning progression focused on teaching concepts of evolution to high school students. This LP was postulated and designed to address the issue of high school students finding difficulty in understanding the concepts behind the process of evolution even though the theory has been well defined through the years (Bishop & Anderson, 1990; Ferrari & Chi, 1998). Additionally, students have many misconceptions regarding evolutionary theory and how populations of organisms change over time (Anderson, Fisher, & Norman, 2002; Rudolph & Stewart, 1998; Shtulman, 2006). The authors went about designing the project by collecting initial responses from students and linking them to Mayr’s ‘five facts and three references’, which was used as the main description of evolution (Mayr, 1980, p 479-490). Through analyses of students’ responses and assessment results, the theoretical LP generated was iteratively refined to represent the initial construct. The assessment given served the dual purpose of informing teachers about students’ ideas on natural selection before administering the unit, and measuring changes of these ideas after administering the unit using the LP methodology. Initially, a four-step, hypothetical LP was created and used to explain Natural Selection in the first year of this project. This construct included big ideas, descriptions, and samples of students’ descriptions. Students were given a pre-test, which consisted of a 20-item formative assessment aligned to Mayr’s facts and inferences. After the unit was taught, only 2 schools participated in administration of the post-test to students. Through analysis of these results, changes and revisions were made to the assessments. Although this project was a multi-year effort, the ideas can be altered for use in a shorter period with a smaller sample set of students (Furtak, Morrison, Iverson, Ross, & Heredia, 2011).
Through a careful review of the published LP models available at the time, Corcoran, Mosher, and Rogat (2009) arrived at five essential elements of an effective LP. First, the learning goals of the model must be created based upon discipline, social connections, and preparation for the next logical step in education. Second, measures of progress must be grounded in application and practice, and checked throughout the process. Third, steps in achievement must express student thinking and progress. Fourth, opportunities must exist for students to demonstrate their knowledge appropriately. Finally, assessment(s) must be attached to measure student progress.

Science LPs include the above elements and are similar to other fields in that they are empirically tested and dependent on instruction provided to the students participating in the framework. However, they differ from other disciplines mainly because they are developed through research in science education, psychology, and other social science fields. A science LP begins with research into relevant literature and data pertinent to the domain or concept being taught. From this, a few elements or components that comprise the central ideas of the sequence are developed. Next, sets of initial assessments are developed to determine students’ prior knowledge on the topic, followed by frameworks to compare and contrast levels of students’ knowledge. Finally, hypotheses are designed to be tested at different levels of achievement, where students can transition from lower-level thinking into complex, analytical thought processes (Mohan, Chen, & Anderson, 2009).

Science LPs can last from upper elementary school into high school (Hess, 2008; Mohan, Chen, & Anderson, 2009; & Duncan, Rogat, & Yarden, 2009). Based on the research, a LP sequence describing the concept of genetics that would span one year of high school, specifically a 10th grade biology class would begin with the teacher implementing a pre-assessment to
determine how much prior knowledge students have about the topic. Using this information, lessons would be designed to cover the overarching ideas of genetics, both classical and modern and the teacher would also outline how much knowledge students should attain by the end of the course. Lessons would include introduction to new vocabulary, diagrams, schematics, and involve laboratory practice as well. The biology teacher would also create a set of targeted goals students should achieve throughout the year that are aligned to the students’ learning levels and abilities, along with methods to measure their progress through formative assessments including projects, presentations, quizzes, and exams. Finally proper summative assessments to validate the sequence of learning would be administered and analyzed (Duncan, Rogat, & Yarden, 2009).

The framework for science LPs was created out of a desperate need for the reliability, advancement, and success of students in the scientific disciplines, and the ability of U.S. students to compete on the world stage in science. Data show that U.S. students are still far behind many other developed countries in both science and mathematics (Gonzales, Williams, Jocelyn, Roey, Kastberg & Brenwald, 2008). High achievement in these fields is necessary for our students to pursue scientific careers, drive innovation and technology, and participate in worldwide agendas such as climate change, environmental issues, and genetics. At the very least, our students must be scientifically literate to become informed citizens when they enter the workforce and family life (Corcoran, Mosher, & Rogat, 2009).

LPs can be applied to teacher education and the way in which teachers learn. For teachers to successfully create and implement a LP sequence, much preparation and professional development is required. Teachers must understand how to recognize the signs that express how students learn, and to develop appropriate learning goals and assessments for knowledge acquisition (Heritage, 2008). Participating in teacher preparation courses (pre-service teachers)
and PD workshops (in-service teachers) primarily focused on the intricacies of science LPs will allow teachers to attain more knowledge in their specific discipline, while becoming more sophisticated and robust pedagogues (Schneider & Plasman, 2011). This study takes one unit of a SLP that has been written and adapts key elements of the unit, including the objectives, learning goals, lesson sequence, formative, and summative assessments and combines it with elements of CRP to create a culturally-relevant biology exemplar for use in a high school classroom.

**Multicultural Science Education.** The United States is built upon the strengths of peoples who have immigrated here for the last several hundred years, and continue to immigrate. By this fact alone, it is clear that American educators must not only be academically proficient but also open to learning about different cultures represented in their school. If an educator enters a classroom with a closed mind and an unwillingness to accommodate students, he/she might be considered obstinate, intolerant, or worse, a bigot. To eliminate these perceived misrepresentations, therefore, it is vital for educators in all disciplines to be exposed to multiculturalism as it relates to education. Students, in turn, will feel respected and appreciate someone who demonstrates knowledge of their native culture and uses it to guide them in their academic pursuits.

What does it mean to be a multicultural educator, and even more, a multicultural science educator? In contemporary urban public school systems there exists a disconnect between the culture of educators and the indigenous cultures of their students (Proweller & Mitchener, 2004). Many new educators lack the basic skills in their content disciplines to effectively impart knowledge, and just as importantly they lack the cultural expertise needed to connect with their students (Proweller & Mitchener, 2004). The need for science teachers to become experts in not
only content but also diverse cultural backgrounds is evident from the racial makeup of students in urban school districts. In New York City, for example, the most recent 2010 census shows 85% of students are categorized as non-White (New York City School Construction Authority, 2013). This is in sharp contrast to the United States teacher population, which is 83.5% White and consists of only 6.7% African American and 6.9% Hispanic teachers (National Center for Education Statistics, 2008).

To understand the role of multiculturalism in the classroom, a definition of culture is necessary. D’Andrade (1990) provided a comprehensive yet succinct definition of culture:

Culture consists of learned and shared systems of meaning and understanding, communicated primarily by means of natural language. These meanings and understandings are not just representations about what is in the world; they are also directive, evocative, and reality constructing in character. (p.65)

Teaching science to nondominant students requires knowing how to achieve success in the context of the social and cultural aspects of both students and teachers. Some of the elements suggested for success include availability of current and reliable resources, accessibility to the scientific community, and culturally relevant teaching, which is a very vital tool for success in diverse settings (Emdin, 2011; Ladson-Billings, 1995). It requires that science teachers delve into the diverse cultures of their students and connect aspects of these cultures to classroom teaching. While students still learn Western science, teachers encourage them to use native ways of thinking, knowing, and interpreting to fully grasp scientific concepts (Barton, 1998; Gondwe and Longnecker, 2015). Something as simple as using an example of an animal from a student’s country can improve engagement and encourage excitement.

As a means of promoting equity for all students, culturally relevant pedagogy (CRP)
offers a conceptual framework to that guides the incorporation of teaching into culture. CRP requires that academic institutions and teachers prepare for, and fully participate in, learning about and using aspects of their students’ cultures. CRP addresses these detrimental factors and provides a formalized tool for reconciling the standards to include students’ native cultures (Emdin, 2011). To become culturally relevant pedagogues, pre-service and in-service science teachers should be fully educated on using appropriate ways to prepare for engaging diverse students such as reflective thinking, meeting with students’ and their families, and appreciating diversity (Richards, Brown, & Forde, 2006). The current curriculum for science is “culture free” and thus does not address the needs of culturally diverse students, essentially negating any input from outside its margins.

For a long time, literature has shown that if educators found ways and means of using native language in instruction, students would be more successful in the classroom (Gee, 1989; Ladson-Billings, 1995; Dong, 2013). Teachers could find opportunities to give students social power in the classroom, and facilitate use of this power to create academic spaces where students discuss academic interests in student-centered settings. Teachers who utilize students’ culture as a vessel for holding and teaching new concepts are also promoting a culturally relevant classroom. For example, using song lyrics to teach poetry in an English class is a very successful way of using something students are culturally connected to (Ladson-Billings, 1995). Even more recently, Christopher Emdin has collaborated with others to create a model called Hip-Hop Education, where students use the genres of rap and hip-hop to describe scientific concepts, thereby using the cultural capital of African American and Hispanic students in an academically positive way (Leland, 2012).

Molding critically conscious students is another example of culturally relevant teaching
where students look at social norms occurring all around them, analyzing them, and constructively criticizing them (Ladson-Billings, 1995). For example, students might be shown a video clip of political commentary on a scientific phenomenon that represents a complete misconception of the facts. Students can then write letters to the network and the politician involved after investigating through literature or experimentation and collecting evidence rejecting what was stated in the video clip. This gives them a socially relevant platform while also building conceptual knowledge through the use of inquiry-based practices like carry out experiments and analyzing literature.

One aspect of becoming a culturally relevant pedagogue is for educators to self-reflect on their own racial and cultural identities (Howard, 2003). Many modern educators recognize that multicultural education is necessary to address elements of racism, diminished self-esteem, and language barriers encountered by disadvantaged and disenfranchised students. Saint-Hilaire (2014) believes that “culturally relevant pedagogy should help close the gaps between students and teachers, students and students, students and curriculum,” and considers herself a strong proponent of using multicultural education to teach students in diverse urban schools. Borrero, Flores, and de la Cruz (2016) interviewed several new teachers of diverse students regarding their understanding and use of CRP in the classroom. Teachers identified a few vital themes in their journey. Importantly, understanding themselves in terms of feelings towards being educators, feelings towards their diverse students, and self-confidence in the classroom was mentioned. These teachers also expressed that to enact CRP strategies successfully, communication with fellow educators and with experts in the field is of great advantage. Hodson (1998) suggests that educators must learn to appreciate and embrace diversities and to arm members of ethnic minorities with the knowledge to defend their cultures and languages in
positive ways. Becoming a multicultural science educator will ensure equity for all students in urban public schools. Thus, educators must pinpoint their own science identities, their students’ science identities, work with administrators to prevent suppression of these identities, and use knowledge of multiculturalism to teach scientific concepts through methods that resonate with students (Fraser-Abder, Atwater, & Lee, 2006).

Figure 2.2 describes a visual representation of how one can link multicultural education frameworks (specifically CRP) with learning progression frameworks, namely the science learning progression framework, as this study does. As shown, learning progressions exist in all disciplines (National Research Council, 2005), and there are many proposed frameworks to describe ways of integrating cultural knowledge into pedagogy such as critical race theory (Larkin, Maloney, and Perry-Ryder, 2016) and hip hop pedagogy (Emdin, Adjapong, and Levy, 2016). Over many years, researchers have addressed issues of cultural differences that occur between students and teachers in classrooms, and have thus developed conceptual and theoretical frameworks that, when implemented in pedagogy, educate teachers into becoming more culturally-knowlegeable pedagogues. The figure also demonstrates the separation that exists between a traditional, academic instructional framework like the Learning Progressions and the more socio-multicultural frameworks. I argue that coupling science LPs and CRP, two well-developed but divergent frameworks, can result in culturally-sensitive and knowledgeable science teachers who will create an enhanced learning environment for culturally diverse students.
Constructivism. There are numerous definitions of constructivism. Lamanauskas (2010) describes constructivism as an epistemology, which argues that humans construct meanings from current knowledge structures; while Tahir (2010) states that constructivism emphasizes that a learner must make sense of science through an existing conceptual structure. Matthews (2002) adds that while constructivism began as a theory of learning, it has expanded its dominion to become a theory of teaching, education, origin of ideas, and a theory of both personal and scientific knowledge. Confrey (1990) describes constructivism as essentially a theory about the limits of human knowledge, a belief that all knowledge is necessarily a product of our own cognitive acts. Liu and Matthews (2005) used a more philosophical approach to
analyze constructivism: that knowledge is not mechanically acquired, but is actively constructed within the constraints and offering of the learning environment. These many definitions converge on one essential theory: constructivism proposes that humans learn by deriving meaning from their prior experiences and preexisting ideas.

Through the course of the last several decades, numerous educational researchers and scientists have examined and probed the closely intertwined relationship between critical thinking and deep questioning. These researchers have used different approaches and analyzed many distinct theoretical backgrounds in their case studies and reviews. A particularly important background examines how students’ questions change as teachers transition from a teacher-centered classroom environment (transmission model) to a more student-centered classroom environment (constructivist model). In the field of science education, there is a plethora of literature that focuses and addressed the importance and benefits of inquiry in the science classroom, which focuses on students constructing new knowledge through a mixture of activities in a student-centered classroom (Akerson, Abd-El-Kahlick, 2000; Crawford, 2007; Roehrig and Luft, 2004). Yet, measurements of inquiry are often noticeably absent in said classrooms (Kirschner, Sweller, & Clark, 2006; Marshall, Horton, & Smart, 2009; Alfieri, Brooks, Aldrich, and Tenenbaum, 2011).

Many consider Jean Piaget, the French Swiss Psychologist, to be the father of cognitive constructivism. Piaget believed that young children can learn and build information by constructing knowledge and making conceptual changes. As they grow even older, their thought processes mature and become higher-level in nature and they begin to have abstract thoughts, which adds to their overall perceptions of the world around them (Powell and Kalina, 2009). In contrast to the emphasis on the student, social constructivism emphasizes the role of the
environment. Vygotsky is the pioneer of this particular stream of thought where the emphasis now shifts to the environment of the individual. Modern social constructivists have chosen to take more practical approaches to their study of the relationship between environment and knowledge. They draw on the influences of race, gender, socioeconomic status, and other factors that directly influence one’s environment (Liu & Matthews, 2005).

Derry (1996) discussed some of the learning environments that must be created to practice constructivist theory. Here, Derry proposed that questions, which activate cognitive processes and understandings or are successful in different learning environments, should be designed appropriately and address cognition as well as learning outcomes. Derry also believed that researchers must realize that all individuals learn in different ways and under different conditions, thus it would be prudent to analyze the strengths and weaknesses of a variety of instructional practices and the learning that occurs in varying learning environments.

Throughout the literature on science and biology, the main theoretical underpinning on how students’ learn/develop scientific knowledge is Lev Vygotsky’s model of social constructivism, where students participate in social interactions to construct, understand, troubleshoot, and validate scientific knowledge (Driver, Asako, Leach, Mortimer, & Scott, 1994; Chin, 2006). The reasons and descriptions above justify why I will use constructivism to guide my analysis and interpretation of the data that is collected using an SLP combined with CRP. The methodologies surrounding the sequence of lessons will follow a student-centered classroom where the students participate in activities and are made to feel responsible for creating the content of the subject using rigorous cognitive exercises.
Literature Review

Routines and Rituals. One of the biggest challenges faced by teachers in urban science classrooms is developing an effective student-teacher relationship. Science teachers (and teachers in general) frequently come from very different cultural and educational backgrounds than their charges in the classroom. Sometimes, this can result in a wonderful atmosphere in which the teacher and students learn about one another’s culture, and the teacher is successful in stimulating student achievement. In many cases, though, a large disconnect instead forms between teacher and students, resulting in classroom conflicts, tension, and misuse of teacher authority. Ultimately, the classroom fails to become a proper learning environment, and both the teacher and students are short-changed. To avoid such a negative outcome, it is therefore essential to consider: How do teachers perceive students? How do teacher rituals and routines influence student behavior, and how do these phenomena affect learning in the science classroom? A ritual can be defined as a pattern that is practiced consistently over the course of the school term. Thus, by avoiding negative rituals and practicing positive ones, teachers can facilitate student success. In fact, strong teacher-student relationships are significant in promoting positive outcomes related to academic engagement and achievement for disadvantaged and at-risk students (Roorda, Koomen, Split, & Oort, 2011).

Before discussing perceived behaviors in classrooms, I would like to examine the concept of deviant behavior as explained by Howard S. Becker in the book, Outsiders, studies in the sociology of Deviance (1963). Becker describes ‘outsiders’ in a few ways. An outsider may simply be an individual who doesn’t subscribe to what is considered ‘normal behavior’ by society. This individual has deviated from the norm; thus, other members of society recognize and define this as deviant behavior (Becker, 1963). Taking the young adult student as the
outsider in this instance, the question arises: why do students practice deviant behavior in the classroom? According to Becker, many factors contribute to a person’s mentality, and for students these factors can be highly influential and far-reaching. One example looks at cases of juvenile delinquents. Do these young people reside in non-traditional homes? Do they live in low-income neighborhoods? Do their academic and intelligence factors play a role in their deviant behavior? Becker suggests that there is a pattern that develops; a ‘sequential model of deviance’ made up of variables that push an individual into particular modes of deviant behavior.

It is vital for urban educators to be aware of the labels given to students who commit initial acts of deviance. Becker stresses that if an individual makes one mistake, commits a ‘crime’, and is subsequently caught, processes are set in motion that can impact future behavior. A student may be pushed into future deviancy if administrators describe him or her as such, resulting in serious consequences to the student’s personal image and social interactions. For example, a student’s peers may become immediately apprehensive about associating with the student, forcing him or her into seeking out a new social group that might encourage future deviant acts (Becker, 1963). It is therefore imperative for educators and administrators in urban high schools to be aware of their treatment of students who have strayed from the correct path, and find ways to guide them back towards success.

The prevention of deviant behavior among students can be achieved in part by the appropriate use of rituals in the classroom.

Traditionally, classroom dynamics called for the teacher as an indomitable authoritative figure, with students as subordinates. This dynamic has begun to shift with the realization that this approach does not offer a conducive learning environment for all students (Tobin, 2006). While research has been published about the ineffectiveness of this mentality, such naïve
thinking persists among pre-service teachers, as many are not familiar with the literature on this subject and teacher-centered continues to persist in many science classrooms (Felder and Brent, 2005). As another example, teachers may unwittingly display preferential treatment towards students who are in better academic standing without realizing the effect elicited on other students. Research has shown this type of behavior can cause serious psychological effects in students, and lead to classroom conflict between teacher and students (Chiu, Lee, & Liang, 2003).

One approach to ameliorating the damage of negative rituals is to assign a mentor to provide guidance to new teachers. An effective mentor would function as a coach, helping novice teachers not only academically but also to help them improve their relationship to students and to find effective rituals and routines for each individual class setting (Carver & Katz, 2004). While such rituals may not be effective for every student, the teacher must develop a few simple routines and guide students early on how to follow them, thereby creating an organized classroom dynamic (Sterling, 2009). Developing a measure of routines at the beginning of one’s teaching career is necessary to ensure that classroom management issues are minimal, and that instruction takes place (Kagan, 1992).

In addition to avoiding negative rituals, through self-reflection, experienced science teachers can create ritualistic practices with students to reward positive behavior and promote engagement. One effective ritual for teachers to encourage positive attitudes among students is to show them praise and encouragement, and express a friendly attitude. This also helps students in science classrooms become more engaged and receptive towards learning (She & Fisher, 2002). Moreover, as science teachers gain more practical experience using routines, they can adjust their format when the norm fails to work (Levin, Hammer, & Coffrey, 2009).
Another example is the encouragement of all students, even less-expressive students, to partake in class discussions by creating a ritual whereby each student answers questions sequentially or alphabetically. This approach ensures that each and every student participates in the lesson. In another simple ritual, the science teacher may perambulate the room to create a comfortable atmosphere, rather than standing at attention in the front of the classroom or sitting at the teacher’s desk. Byrd-Blake et al. (2010), in describing the low morale and high pressures faced by many teachers in high-risk schools, suggest allowing science teachers to create modules of student-centered activities. These activities could serve as positive rituals replacing the normal standardized test-preparation sequences forced upon teachers.

Science teachers face a slew of uncertainties, issues, fear, and deficiencies when they choose to practice their art in high-poverty public schools. However, by taking the initiative to turn perceived negative behaviors into positive outcomes, and by creating positive routines and rituals in the classroom without becoming strict authoritarians, they can succeed in helping these underprivileged students construct scientific knowledge and become excited about science. Through continuous critical self-reflection of their teaching practice and various stylistic traits, in-service science teachers can fine-tune the benefits of certain routines and rituals in their own classrooms and use this information as a positive influence, especially amongst students who are considerably less motivated than others. Creating a safe, comfortable, constant environment for students will ensure feelings of equality from all and encourage all students to try their best. By combining elements of CRP with routines and rituals in the science classroom, students will feel a sense of appreciation and value in an equitable learning environment.
Science Teacher Education Programs and Professional Development. An approach to teaching science in a multicultural setting involves using examples from diverse backgrounds to empower students, create settings for social construction of knowledge, facilitate development of higher-order thinking skills to predict, analyze, and justify conclusions, and suggest projects that involve social and personal pursuing related to the scientific issues being studied (Bianchini, Johnston, Oram, & Cavazos, 2002; Mensah, 2011).

Pre-service teacher preparation. Student-teaching opportunities should allow pre-service science teachers to interact with culturally-diverse students as a means of being exposed to the cultural and social norms of the society they are about to encounter that will support their science teaching and interactions with students (Gunning and Mensah, 2010; Suriel & Atwater, 2012; Windschitl, Thompson, Braaten, & Stroupe, 2012; & Yerrick, Schiller, & Resifeld, 2011). In this way, they can create situations for discourse where students contribute to their learning by sharing their experiences, and where teachers can deeply reflect on their practices, and readjust to fit the needs of students first (Yerrick, Schiller, & Reisfeld, 2011).

Another important factor for pre-service science teacher education involves providing opportunities for individuals to create professional identities and teaching philosophies using theories of culturally responsive/relevant pedagogy and social justice. Here, the goal is to integrate diverse student cultures and languages as a means to aid students in learning science (Furman, Barton, & Muir, 2012). Ladson-Billings (1995) states, “culturally relevant pedagogy must provide a way for students to maintain their cultural integrity while succeeding academically” (p. 476). Teachers hold such a meaningful role in the lives of students that pre-service science teacher education must succeed in preparing teachers to understand their beliefs about teaching, epistemology, student learning, culture, race, and class as it affects aspects of
their pedagogy and practice (Bryan & Atwater, 2002; Mensah, 2009).

In-service teacher professional development. With respect to aiding in-service teachers in their quest to become proficient multicultural science educators, forms of professional development (PD) must focus on equipping teachers with the knowledge and skills needed to serve diverse cultural populations. For example, a high percentage of ELLs live in low socioeconomic groups and have difficulty learning English while trying to live up to high academic expectations. Teachers who participate in PDs that use instructional techniques aimed at reaching ELLs not only help these students progress academically, but give them hope and encourage to keep progressing (Johnson, 2011).

The literature related to teaching science to culturally diverse students in equitable ways focuses mainly on using the theory of CRP, which describes methods for all science teachers, at all levels of teaching to learn, adopt, and implement in their classrooms, making it a routine practice. A study conducted by Grimberg and Gummer (2013) using CRP as the theoretical framework demonstrated that providing PDs which made teachers aware of cultural points of intersection and their students’ views on the world helped them tailor more culturally-sensitive lessons and increase learning and engagement. Teachers should also be encouraged to question and make sense of issues of diversity and equity where a knowledgeable PD leader can explain nuances to them (Bianchini & Solomon, 2003).

For future study and consideration, it is vital for consistency to become a leading factor for pre-service and in-service science teachers. Multicultural education must be made available during science teacher preparation courses, and multicultural education-based PDs must be offered to current teachers. Teachers should be kept informed regarding reforms and policies related to their fields, especially when new standards and new instructional frameworks are being
thrown at them. They must also be allowed the opportunity to enact, in practice, the kinds of instruction that are required of them by those in charge. Professional development workshops must focus on providing biology teachers with the ammunition to facilitate the construction of knowledge in biology classrooms

**Biology Science Education.** Traditionally, biology teachers focus on high-stakes test preparation strategies as the template for instruction. While this can increase student performance in the test, it does not expand overall knowledge of concepts or give students the high-level skills needed to answer complex scientific questions (Popham, 2001). A more effective method is for biology teachers to be immersed in sustained PD workshops that demonstrate the use of inquiry-based practices as a technique for achieving socially-constructed biology knowledge. Greenleaf, et al. (2011) also stresses the necessity of high literacy proficiency in biology to allow reading and writing using complex terminology. Biology teachers must also have strong content knowledge base for effective teaching, thus PD designers must provide occasions for teachers to enhance/expand their content knowledge (McConnell, Parker, & Eberhardt, 2013).

To successfully assist biology teachers to become experts at creating, implementing, and facilitating inquiry-based lessons, PD opportunities need to be relevant, consistent, and intensive (Baker et al., 2004). Workshops must cater to teacher-student relationships as defined by specific school setting and address diversity and equity. Biology teachers should be able to immerse themselves in developing questioning techniques, increasing content knowledge, and practicing experiments as students would. Allowing teachers to demonstrate elements of the skills learned has been shown to give them the driving force to use inquiry in their biology classrooms, and teachers agree that these skills increase students’ abilities to practice higher-

Coupled with opportunities to enhance multicultural science education practices, PDs that aid biology teachers to implement and facilitate inquiry-based lessons will ensure these teachers are equipped with an arsenal of knowledge, skills, techniques, and ideas towards their efforts of bringing biology and other sciences into the lives of students.

Using the theoretical frameworks presented in this chapter as well as the principles surrounding routines and rituals, pre-service and in-service teacher education, and specifically applied to a high school biology classroom, this study will use traditional qualitative research methods to gather data regarding the use of a biology unit of a science learning progression that has been modified to include culturally relevant pedagogical elements in an urban high school classroom. While I mentioned modifications to pre-service teacher preparation programs are needed to ensure substantial multicultural course offerings are provided, the major focus of my study will be on observations of an in-service science teacher implementing the SLP-CRP unit. The next chapter discusses a brief pilot study conducted, which provided initial responses concerning the depth of knowledge carried by science teachers regarding science and multicultural frameworks, and also describes my methodology for the current study.
CHAPTER THREE
PILOT STUDY AND METHODOLOGY

Pilot study

Previously, I conducted a pilot study as part of the requirements for a science education course where I interviewed three science teachers about their knowledge and preparation for teaching not only diverse students, but utilizing available frameworks developed through education research. The following is a narrative of the results obtained from this brief study.

Results

Data collected and analyzed from the pilot study indicated five major themes among the three science teachers who participated. Firstly, all science teachers were unfamiliar with the theoretical frameworks of science learning progression and culturally relevant pedagogy. None of the three had ever heard of a learning progression, but they all attempted to discern meaning from the name. One mentioned scaffolding as an element of a science LP, another mentioned using pre- and post-assessments to gauge student understanding, and the third science teacher discussed building upon fundamental knowledge and going deeper as a progression to learning.

The second interview question was an attempt to elicit a response from my interviewees regarding how a science LP could be a successful framework for teaching science to students at all learning levels. While they were still unsure of the exact nature of a LP, the idea of scaffolding concepts and information from simple to complex was mutual. Ms. JM’s response was the most aligned to how a LP would be implemented. In her answer, she mentioned that “in any discipline, whether it’s math a student needs to know how to add before he can learn how to multiply and learn how to subtract before they really can conceptualize division.” Her description of teaching simple, fundamental concepts as a baseline before students learn complex
material was evident when she said, “a lot of the ‘what’ type questions take me to my ‘why’ and ‘how’ questions.”

The interview questions then took a turn away from LPs and towards multicultural education and how well science teachers were educated to teach in a multicultural environment. I inquired specifically about each person’s teacher-preparation experiences, and all three had either no formal experiences or could not remember being educated to apply multicultural education. For this question, the newest science teacher, who was still working on her graduate degree at the time, stated that “it was implied that we knew we would be working with students of different cultures but we were never really taught how to teach them.” All training was gained from experiences in the classroom, learning as she went along. One response was a little startling. Ms. JM said:

I’m going to answer that really honestly. I remember seeing a course name that said ‘multiculturalism’ but I don’t remember anything about it and even to this day I wouldn’t know what that really means. Because I don’t know that learning is cultural. I feel that a lot of learning issues are socioeconomic. I don’t think that there’s any particular ethnic group that doesn’t value education, and one that does.

This response is a reason why science teachers must continue to participate in ongoing teacher education opportunities where they can become familiar with theoretical frameworks that are being developed and used in education research, and to learn how to engage with students from diverse backgrounds in meaningful ways that will enhance learning. It is astounding that a seasoned science educator who has been in an urban school setting for most of her seventeen-year career believes that students’ cultural upbringing plays no part in their learning. Her
response also suggests to me that her approach to students is possibly very rigid, strict and disciplined, with no room for flexibility or approachability.

Regarding teachers’ familiarity with students’ cultural backgrounds, two of the three agreed that a more intimate understanding of different cultures would assist teachers in creating ways to engage students in science. Ms. CL mentioned that students might not be engaged with science in the classroom because they cannot relate to what is being taught. Here, a teacher’s knowledge and use of students’ cultural subtleties would create a space for all learners to feel comfortable, thereby motivating them to learn science. Ms. JM once again responded that she believed culture is not a part of learning, underscoring my argument that science teachers need to be continuously educated on theories of how students learn best.

The final question addressed whether student engagement in the science classroom would increase if teachers were more culturally aware of their differences and utilized this awareness in a positive manner. Again, two out of three agreed that more cultural knowledge would help, not hurt students. Ms. CL gave a powerful response to this question:

A lot of times you have a student from some sort of minority (group) and the teacher is not. So the student automatically goes to “you have no idea what I’m going through.”

Based on having a good relationship with the student (will) make them potentially more likely to be engaged with the subject matter and even just coming to class or caring about the subject. They want to have the teacher be proud of them and their accomplishments. Her acute awareness of the fact that the student-teacher relationship is a vital part of learning is evident in this response. Students respond well to teachers who show them compassion and empathy and give them opportunities not just to build knowledge, but to become better human beings. While Ms. CL expressed agreement, Ms. JM did not. She stated that the
standardized exams students take at the end of the school year does not address students’ cultural differences, but only focuses on academic material, thus educators are, “in a sense (doing) a disservice to our students to keep revisiting culture.”

Discussion

From these responses, it is evident that although many teachers experience several years of formalized education training through teacher preparation programs and ongoing PD opportunities, unless there is a deeper conversation happening within specific schools and departments about equity and diversity, educators may not understand how to incorporate culture into learning. This study demonstrates the need for the development of a science LP that already contains elements of CRP and can be easily followed and used as a guide. The results of the previous pilot study demonstrate the feasibility of carrying out a more extensive study on combining an academic framework (SLP) with a multicultural framework (CRP) to enhance learning in diverse classrooms.

Methodology for current study

Upon completion of the proposal process, institutional permission was requested through the Institutional Review Board from Teachers College and from the New York City Department of Education. I used data from the New York City Department of Education to select a high school that fits the criteria of being in a high-risk urban area, serving students who come from low socioeconomic standings, are culturally diverse, and are at risk of failing science based on school statistics. Next, a meeting with the Principal of the chosen school took place in order to present my initial hypotheses and ideas, and to gain permission to carry out my study observing biology teacher(s) and their methods of teaching over the course of a pre-determined time. My study design included elements of a science LP and CRP, observations of a science teacher, and
creating and implementing short PD sessions for the teacher participant. My work involved analysis of interviews with education stakeholders about planning, pedagogy, pre-service training, student-teaching experiences, science learning progressions, multicultural science, and any qualitative data offered during the classroom observation processes.

The framework of Science Learning Progressions (SLP) guided the proposed work, with input from the Culturally Relevant Pedagogy (CRP) framework because of the involvement of culturally diverse students. Since I could not implement a SLP from early grades, I used elements of the framework, and collected as much data as was available to interpret and analyze how students’ prior biology classes have prepared them for rigorous high school biology. Elements of CRP was integrated into a science unit to be implemented in the classroom and became the guide for some of my interviews with science teacher(s) and student observations, and I finally coded and analyzed the data obtained using these guidelines.

Research Approach

The current study. This dissertation study was conducted using an intrinsic qualitative case study design. Merriam (2009) defines a case study as “an in-depth description and analysis of a bounded system” (p. 40) while Creswell (2013) describes it as “a methodology: a type of design in qualitative research that may be an object of study, as well as a product of inquiry” (p. 97). I have chosen to look at how science teachers in an urban public high school perceive and implement a science learning progression (SLP), and how students create conceptual knowledge as a result of an SLP. I incorporated elements of multiculturalism, specifically Culturally Relevant Pedagogy (CRP) into a SLP for the final part of this study. The science classroom was the bounded system of this study.
As a science teacher in an urban public high school, I have taught culturally-diverse students at every stage of my education career. My interest in analyzing how aspects of CRP can be integrated into a science instructional approach was sparked at the beginning of my career when I realized that there was a lack of multicultural awareness among my colleagues, which placed them at a disadvantage in the classroom. Our professional development offerings targeted graduation rates, academic outcomes, and standards, but lacked focus in the social aspects of students. I developed deep bonds with many of my students and my desire to see them succeed both personally and academically grew astronomically. As I reflected on my upbringing and my educational experiences, I realized that even though my students and I were brought up in different cultures, many of our social experiences overlapped. My position as not only a teacher but as an education researcher now allowed me to address issues and challenges faced by diverse students with the intention of effecting positive changes in the future.

Setting and Participants

This study took place inside two urban public high school classrooms in New York City, during regular school hours of 8:25am to 2:40pm. I chose a statistically low-performing public high school whose student body is made up of diverse minority students, who traditionally struggle to be engaged in science. The goal was to encourage these participants in a highly positive way that results in science teachers enhancing their cultural understandings of diverse students along with students successfully making personal connections to science through a SLP that is intertwined with CRP.

Participants included four high school science teachers (three biology and one chemistry), one administrator (an Assistant Principal), and forty high school students enrolled in a science course. A science coach working directly with the current New York City Department of
Education Schools Chancellor was also a participant. My study involved the use of a science learning progression instructional framework for teaching science that aims to teach scientific concepts at a deeper and more sophisticated level, with the goal of gradually increasing complexity, and overall understanding by students.

The teacher participant whose classroom was the focus of my third research question, was selected and introduced to me by the Principal of the participating school. This urban public high school is located in a large building that house a total of seven middle and high schools with roughly four hundred to five hundred students enrolled in each school. This school was not my school of employment but located in the same building as my school of employment. I was professionally associated with the Principal, who graciously allowed me access to this science teacher and her students. The teacher had full discretion in choosing the students that I would ultimately observe, introducing a level of teacher bias into the equation since she clearly chose a class that she thought would easily cooperate with the introduction of a stranger and a change in her teacher methods. She was also made fully aware of the intentions of the study and how I would be approaching the students during my classroom visits.

**Data Collection**

*Semi-structured interviews.*

To address my first research question, semi-structured interviews with the science teachers, administrator, and the coach provided information and data regarding the extent of scientific knowledge and methodologies that they possess and employ in their respective classrooms. Importantly, I was able to excavate the landscape of SLPs and CRP in New York City education stakeholders. The data collected was analyzed for overlap and departure of ideas surrounding the proposed frameworks. These ideas can then be separated and utilized to create
future PD sessions. The questions asked of adult educators were carefully structured to provide an in-depth, comprehensive picture of participants’ conceptual understanding of the framework of Learning Progressions in Science (See Appendix B). These interviews also addressed how much knowledge teachers and administrators possess on multicultural education and obtained from their pre-service educational experiences or from in-service PD sessions. Thus, the interviews served as the initial identification of LP preconceptions held by teachers.

I conducted one interview with the teachers and administrators. They were conducted in a mutually agreed location within the school building lasted approximately twenty to twenty-five minutes. I followed up with post-implementation semi-structured interviews (of similar length and content) that gauged the teacher’s perceptions of implementing these frameworks in the classroom. These steps ensured the collection of robust qualitative data that would be thoroughly analyzed and coded. I also collected samples of lesson plans, and other artifacts to analyze for usage of framework elements.

Development of SLP and multicultural PD sessions

To address my second research question, which involved how school leaders and educators can go about providing professional development to in-service science teachers on using SLPs and CRP in the classroom, I analyzed the literature including publications from the Consortium for Policy Research in Education (CPRE) at Teachers College, Columbia University. The CPRE group has been instrumental in providing published literature surrounding SLPs and through their work, has informed the science education research community on the benefits of using SLPs as a new method of pedagogy in K-12 education.

Using this plus other published information on professional development workshops as well as my own experiences creating and implementing these training sessions, I prepared a set
of informal PD sessions aimed at familiarizing the teacher participant with the nuances of the conceptual frameworks being used.

To obtain information regarding multiculturalism and CRP, I analyzed published articles on culturally relevant pedagogy, annotating copious amounts of information for use. Using this information and knowledge, I adapted culturally relevant strands, inserting them into the science unit of instruction using CRP assertions.

Professional development effectiveness

In 2009, Corcoran, Mosher, and Rogat of Teachers College published a manuscript titled ‘Learning Progressions in Science, an Evidence-based Approach to Reform,’ highlighting the key features of the novel theoretical framework, the potential benefits of using this approach, and several examples of science LPs across scientific disciplines of Physics, Chemistry, and Biology. Ladson-Billings (1992) suggested the use of ‘Culturally Relevant Teaching’ as a way to ‘use student culture as the basis for helping students understand themselves and others, structure social interactions and conceptualize knowledge’. While this framework for Culturally Relevant Pedagogy was postulated around helping African American students, I argue that the tenets of CRP can be and are useful for helping all students of color, especially those in urban classrooms. This information provided me with guidelines to assist in the creation of a PD sessions for science teachers to become familiar with the framework.

Once IRB approval was confirmed, I was introduced to a biology/chemistry teacher by the Principal of the high school selected to be the focus of my research. For this study, I had access and permission to work with only one teacher, and I observed a class that was taught by her.

To begin her education of the theoretical frameworks, we met four times outside of the
classroom. She was provided with literature that I collected and organized in a manner that would be simple to follow and understand. We had open discussions about how these frameworks could be used. Ample opportunity was provided to field questions, address concerns, and gain an overall working knowledge of how to implement the frameworks in science disciplines. The participant had full discretion as to which topic would be used and when the unit would be executed as the sequence of content dissemination was already mapped and determined for the school year. During our PD sessions, we worked on incorporating CRP elements into one biology unit. We discussed and looked at examples of SLP units that have been published as well as how to incorporate strategies of CRP into a specific science unit for implementation in the classroom. We discussed ways for her to implement CRP strategies while maintaining high standards of rigor with her students. The unit was intended to guide her pedagogical practices both when designing lessons and executing them in the classroom. It was apparent that rigorous, high level instruction would be retained even with the use of CRP aspects. To ensure understanding and rigor, we collaborated to design a lesson that incorporated both frameworks. Due to anticipated time constraints, the unit sequence encompassed only one unit of teaching (reproduction) for the biology course. While I assisted her, she mostly created the unit plan with questions and tasks for implementation in her classrooms. The classroom that I would observe was taught by her. This classroom would be taught using the SLP-CRP unit plan, which would be an exit from the traditional unit plan designated by the school. Upon completion of the PD sessions and to facilitate critique and review, I provided the participant with relevant literature and documentation and included a questionnaire (See Appendix C).

The teacher participant read and analyzed the literature provided to gain personal insight into the uses and benefits of the frameworks. Together, these approaches allowed collection of
purposeful feedback about the elements of the proposed framework. She was instructed to carefully answer the questionnaire, which provided data regarding her perceptions, understanding, comfort-of-use, encouragement-for-use, and suggestions for improvement of the session. I would therefore be able to utilize this data to modify and enhance future sessions.

Implementation of a SLP that has been modified to include elements of CRP

A modified version of a reproduction unit created by New Visions (2017) was used (See Appendix E). The teacher used many of the components of the unit such as the objectives, performance tasks, and many of the activities as well as the suggested lesson sequence. Additionally, she modified some of the activities and incorporated her own textual material. For students in high school, this unit is made up big ideas that are further subdivided into components. These components are directly aligned to standards in the New York State Living Environment Core Curriculum, Standard 4, Key Idea 4 (See Appendix F). Qualitative data was collected for further analysis and coding for specific phrases that indicated the extent of students’ knowledge building. I also observed the interactions between the teacher and students as well as interactions amongst students. Misconceptions that many high school students tend to have about certain scientific concepts in the unit become apparent during these classroom sessions. Identifying misconceptions during the early stages of this new process allowed revisions to be made for future classes.

While observing lessons, I listened for key terms and the use of accurate scientific language from students while they participate in relevant discourse. For example, if the lesson being taught in the classroom that day focused on how mutations in human DNA can be harmful, I would have listened for the use of science jargon such as ‘genes’, ‘variations’, ‘DNA sequence’, ‘amino acid sequence’, ‘protein’, etc., to indicate students deeper understanding of
the concept. In terms of reproduction, I listened for terms such as ‘fertilization’, ‘egg’, ‘sperm’, ‘gametes’, ‘development’, ‘types of fertilization’, etc.

During this phase of the research study, the teacher participant was asked to use a SLP that was modified to include several elements of CRP that we had collaboratively created during PD sessions (See Appendix I). To collect data, I attended and audio recorded lessons involved in this unit as well as making copious notes whilst the lesson was underway. The teacher was interviewed before these lessons were executed and after the entire unit was disseminated to the students. The teacher participant was able to express views about the framework, such as which elements were successful in creating conceptual understanding, and what could be changed or improved in the future. I also perambulated the classroom, observing and carefully listening to student discourse, while looking for use of scientific terminology in conversations. Proper use of scientific terms indicated conceptual knowledge building and reinforced the use of this framework to teach students in urban high school populations.

*Step-by-step procedures.* For added clarity, below is a step-by-step methodology used to carry out the major steps in this study:

1. After determining the context of the study, developing my research questions, and getting IRB approval, I created different components that I would use during the study.
2. Firstly, I wrote several questionnaires, including semi-structured interview questions for teachers, the administrator, the coach and student participants involved.
3. To create the SLP-CRP exemplar, I looked into existing SLP units that could be adapted for use in the science classroom being observed. Fortunately, the New Visions curriculum was being used by the school involved. This would serve as the unit of
instruction for the intervention classroom. Using published literature on CRP, elements that could be incorporated into the unit were identified.

4. I collated informational literature for the teacher participant to train and familiarize her with the SLP and CRP frameworks. We had four informal meetings where we initially discussed the students and classroom that would be observed, then the unit of instruction that would be taught. She had already begun the school year using the New Visions living environment curriculum to guide instruction.

5. Together, we created a reproduction unit that combined elements of CRP with the biology reproduction unit of the New Visions curriculum. She mapped out a unit plan, daily lessons and objectives, handouts, questions, group activities, rubrics and assessments (see Appendix J). This unit plan would be used with additional CRP elements incorporated into discourse with students.

6. I introduced myself to students in an initial classroom visit, giving them opportunities to ask questions once I described my purpose and asked for written permission (and received written permission from their parents). They were informed that if they chose not to participate, I would not collect any data about them specifically. However, all students agreed to participate.

7. Once these permissions/consents were received from both parents and students I initiated my classroom visits to two separate biology classrooms.

8. I observed the classroom two to three times per week for about 3 months while the teacher instructed on the biology reproduction unit. I audio recorded interactions and discourse, and took copious notes on discussions, student-teacher interactions, student-student interactions, and any other observations that I deemed important.
9. The teacher participant was given a questionnaire as well to complete at the end of the classroom observations.

10. All data collected from this study was safely stored for future analysis and interpretation.

11. Data from the SLP-CRP classroom and the traditional classroom, including classroom observation notes and audio recordings were analyzed and coded manually and using the NVivo qualitative analysis software system.

Table 3.1: Summary Table of Research Questions

<table>
<thead>
<tr>
<th>Research Questions</th>
<th>Data Collection Procedure</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. How knowledgeable are educators about the use and implementation of Science Learning Progressions and Multicultural Education methods?</td>
<td>Semi-structured interviews</td>
</tr>
<tr>
<td>2. How through professional development do we integrate Culturally Relevant Pedagogy with parts of a Science Learning Progression for teacher learning?</td>
<td>Semi-structured interviews, Questionnaires, Audio recordings</td>
</tr>
<tr>
<td>3. What does the use of a science learning progression integrated with elements of culturally relevant pedagogy look like in a science classroom?</td>
<td>Semi-structured interviews, Questionnaires, Audio Recordings, Observations, Student Artifacts (worksheets, summaries, etc.), Lesson plans</td>
</tr>
</tbody>
</table>

Data Analysis Methods

Using methods described in Merriam (1998), qualitative data collected during this study were analyzed for emergent themes and reported.

RQ 1.

Interview data. Information collected from semi-structured interviews with teachers and administrators were manually transcribed and organized into separate files electronically. I transcribed this audio data. To begin the coding process, initial transcripts were carefully read
through several times for identification of big ideas and possible emerging themes using the research question as the guide. Transcripts from the biology and chemistry teachers, the administrator, and the coach were carefully summarized to include relevant initial codes that were related to the research question. I developed a coding scheme based on initial interpretations of interview data and used this scheme to identify clusters among participant responses using the invivo coding method, where short phrases were assigned to sections of data in the transcripts that bore similar responses. From this, emergent themes arose for further interpretation and reporting.

*RQ 2.*

_Professional Development:_ Published literature was carefully analyzed and utilized for creating PD sessions to inform and educate the teacher participant (Joyce and Calhoun, 2015; Van Der Klink, 2016; Baker et al., 2004; Steeg and Lambson, 2015; King, 2014; Avidov-Ungar, 2016; Penuel et al., 2014; Banks and McGee, 2004; Cocoran, Mosher, and Rogat, 2009).

Once the sequence of the PD sessions was created and written, all materials were provided to the participant. We met four times before I began classroom observations. In session one, we discussed her interests in being a science teacher and choosing an urban high school for her career. I orally informed her about the study goals and my perceptions of how she would participate. I described my methodology to give her the full picture of what I would be looking for during my classroom visits. She also chose a class that she felt confident in enacting this new mode of pedagogy with. The students in this classroom were more cooperative and would readily respond to new strategies. She would employ different modalities of teaching using the SLP-CRP unit in her classroom instead of traditional teaching methods. We discussed the class that would be appropriate for observations and how many students were enrolled in the
class (there were twenty-five students altogether). Once our discussions turned to the theoretical frameworks, I presented her with initial literature on SLP and CRP (Heritage, 2008; Nichols, 2010; Duncan, Rogat, and Yarden, 2009; Ladson-Billings, 1995). These would help familiarize her with the theoretical frameworks that would be used. In session two, I presented her with a PowerPoint presentation that I put together where I simplified the major principles of both SLP and CRP. We discussed the literature in depth and started thinking about the unit of instruction that could be used in the intervention classroom. We also noted that the New Visions curriculum was written in a SLP format and was suitable for this study. We discussed her students and how she felt about the differences in culture between her and them and how she could reconcile these differences in a positive way. In session three she suggested the reproduction unit, which we analyzed more closely. Together, we discovered ways to incorporate CRP assertions into her everyday lesson sequences. We spent the remainder of this session and the final session tweaking the unit plan that would be implemented. In the classroom, she would give students multiple points of entry into a topic by using different strategies such as high-level questioning, collaboration, student-centered discussions, and activities. The same topics would be taught but she would move away from teacher-centered approaches that were strictly academic and used consistently throughout her school. After our sessions, she completed a questionnaire regarding her perceptions on the effectiveness of the PD sessions, which I then analyzed and interpreted.

*RQ 3.*

_Lesson plans, focus group data, and written observations._ I analyzed data for discourse in the classroom that included questions and prompts, and use of specific scientific terminology during conversations, which indicated that students were integrating their personal experiences into lesson topics in the classroom using CRP. Student-teacher conversations were also carefully
recorded and stored. All written data was carefully collected, labeled, and separated into relevant categories, which included teacher data and student data. Audio data was downloaded and sent out for transcription by a professional service then emailed to me once completed. I began analyzing data by carefully reading documents and looking for initial codes among participants. I read the data line by line to identify common codes among participants. These codes were clustered together to identify emerging themes that have been reported in this manuscript.

**Rigor**

When researchers choose qualitative methods to carry out studies, they consider many aspects that may not be analyzable using quantitative methods. According to Creswell (2007), qualitative research will be highly rigorous and accurate when all elements are properly designed and followed. Quantitative research is more concerned with developing and testing hypotheses, using different models and/or theories to test predictions and making results more generalized across samples. Data produced is usually numerical and inflexible, and supported by analysis using statistical methods, thus making results highly valid (Hoy, 2010). However, because my study is novel, I only collected, recorded, analyzed, and interpreted qualitative data as an initial evaluation of the questions asked. A qualitative case-study design allowed me to interpret philosophical data collected through interviews, student artifacts, questionnaires, and audio recordings. Using the tenets of qualitative research to compare and contrast elements of the study provided a robust, highly valid set of results that was clearly explained and interpreted and provide more believable and persuasive information.

Philosophical assumptions related to epistemology and ontology are elements of qualitative research, and when carefully designed result in highly valid, reliably results
(Creswell, 2007). Epistemologically, a qualitative study is interpretivist because the researcher searches for meaning through the social environment of the study participants. Ontologically, qualitative research is constructed over time through different contexts and events (Ali-Bapir, 2012).

The validity of this research study was demonstrated through the credibility (believability) of collected data as well as the ability to transfer this data to other contexts. Data and conclusions was correctly correlated using qualitative analysis methods that ensure validity and interpretability.

Hammersley (1992), defines reliability of qualitative data as, ‘the degree of consistency with which instances are assigned to the same category by different observes or by the same observers on different occasions’ (Hammersley, 1992, p.67). To ensure highest reliability of this research study, several different methods of data collecting and analysis was employed. All procedures were carefully and correctly documented. During the analysis process, designated categories were reported and used consistently throughout the entire course of the study.

Through the use of carefully designed methods of data collection, as well as use of different procedures this research study has attempted to maintain the highest levels of validity, reliability, and rigor.

**Ethics**

Ethical issues in qualitative research can be subtle as compared to challenges that arise during quantitative studies (Orb, Eisenhauer, & Wynaden, 2001). This study was conducted using teachers and students involved in science courses in public high school. Before initiating the study, approval from the Institutional Review Boards of both Teachers College, Columbia University, and the New York City Department of Education was sought and obtained. Teacher
and student participants were verbally informed and given consent forms to review and sign. Parents of students were contacted through phone calls and letters giving them full disclosure of study methods and how students were involved. No real names were ever used to protect the identities of all participants.

All aspects took place in a professional school setting, during school hours. Participation was strictly voluntary and students were informed that if they chose not to participate they would not be observed or recorded. However, all students (and their parents) agreed to participate. Students were not compromised in any way as this study strived to mainly observe how they interact among themselves and with the teacher. The students who participated were given full disclosure on how the data collected would be utilized.

As a high school science teacher, I believe all students, regardless of ethnicity, race, or culture, can learn science, but face challenges based on factors such as socioeconomic status, and language to name a couple. The purpose of this study has been to identify a framework that can enhance the way science is taught to diverse students in urban public high schools.

Role of the Researcher

For this dissertation study, and regarding the science teachers, administrator, and the science coach my role was understood to be the interviewer. Two teachers and the administrator worked with me and two teachers worked in the participant school. Classroom observations were not conducted inside my place of employment, therefore the students were not familiar with me. The students only made contact with me when I conducted classroom observations. To achieve a level of comfort between myself and the students, I visited the classroom initially, allowing the students talk to me freely about the study. Once I began the official observations, they knew who I was and did not react negatively to me being in the classroom. They
understood that I was there to observe the lesson sequence, take notes, and audio record conversations.

Expected contributions of research

Using the methods described, I expected to collect a large data set that would demonstrate the benefits of using a SLP sequence in a public high school biology class. I also expected to show that by encouraging science teachers to become more culturally sensitive and involved with their diverse students, they can enhance their pedagogical skills while expanding their cultural knowledge base. By observing students in the classroom, I expected to see improvement in scientific conceptual knowledge building as well as comfortable discourse between students and teachers in the classroom setting. My intent was not to collect quantitative results of assessments to gauge student improvement, but to show that by integrating cultural sensitivity into a traditional, academic science framework, teachers and students in diverse settings can transcend sociocultural and philosophical issues in education to create a highly effective and rigorous learning environment that exudes feelings of appreciation and comfort.
CHAPTER FOUR

RESULTS

Research Question 1: How knowledgeable are educators about the use and implementation of Science Learning Progressions and Multicultural Education methods?

Responses from semi-structured interview questions demonstrate mostly a consistent lack of knowledge or awareness of the term ‘learning progression’ or ‘science learning progression’ and although teachers were aware of multicultural education, most of them were not exposed to formal multicultural education either from their graduate education programs or from professional development sessions as in-service educators.

Results of semi-structured interview questions:

Concerning familiarity and the use of the science learning progression framework.

A total of six education professionals were interviewed, three of them being biology teachers and one chemistry teacher in urban public high school setting in the Bronx, one being a science coach working within the Renewal school program of the New York City Department of Education and assigned to several high schools in the Bronx, and the final individual being an Assistant Principal for almost ten years in an urban public high school in the Bronx. Each person interviewed comes from a different cultural background, have been in the profession for different numbers of years, and have had different educational and cultural upbringings when juxtaposed to students they are responsible for educating. The table below describes each interview participant in terms of their professional roles in education, their number of years of experience in the field, and their ethnicities. This information shows the variety of cultural backgrounds held by these education stakeholders.
Table 4.1: Description of semi-structured interview participants including their role in the school system, years of experience, and ethnicity.

<table>
<thead>
<tr>
<th>Name</th>
<th>Professional Role</th>
<th>Years of experience</th>
<th>Ethnicity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ms. FB</td>
<td>Assistant Principal</td>
<td>&gt;15</td>
<td>Jamaican Black</td>
</tr>
<tr>
<td></td>
<td>Science Coach</td>
<td>16</td>
<td>Mixed race (Hispanic, African American, Panamanian, etc.)</td>
</tr>
<tr>
<td>Ms. MP</td>
<td>Science Coach</td>
<td>16</td>
<td>Mixed race (Hispanic, African American, Panamanian, etc.)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Caucasian-Chinese American</td>
</tr>
<tr>
<td>Ms. CL</td>
<td>Chemistry teacher</td>
<td>4</td>
<td>Jewish-Caucasian American</td>
</tr>
<tr>
<td>Ms. JM</td>
<td>Living Environment teacher (former administrator)</td>
<td>19</td>
<td>Jewish-Caucasian American</td>
</tr>
<tr>
<td>Mr. H</td>
<td>Living Environment teacher</td>
<td>2</td>
<td>African American</td>
</tr>
<tr>
<td>Ms. AZ</td>
<td>Living Environment teacher (also teaches Chemistry and AP Biology)</td>
<td>3</td>
<td>Jewish-Caucasian American</td>
</tr>
</tbody>
</table>

The first individual, Ms. FB has been an Assistant Principal (AP) in an urban public high school in the Bronx for almost ten years. She is of Black (Jamaican) descent and was an English teacher before becoming an AP. In her role as an instructional supervisor, she is responsible for science teachers as well as teachers in other disciplines. She also taught high school English for over five years in her native Jamaica before migrating to the United States.

Ms. MP, the second participant is a mixed-race (African American, Hispanic, Panamanian, etc.) science coach working with the New York City Renewal schools program. Before coaching, she taught science at the elementary and middle school levels for fourteen years. She is assigned to several public high schools in the Bronx and provides instructional coaching strategies to science teachers.

The third, Ms. CL completed her fourth year as a chemistry and living environment teacher in high school. She is of mixed race descent (Caucasian and Asian American) and completed her undergraduate degree in Pre-Med and Movement Science before joining the New
York City Teaching Fellows program, where she trained for six weeks and worked on her Masters in science education while teaching.

The fourth individual interviewed was Ms. JM. She is a Jewish-Caucasian American, veteran science teacher, having taught for nineteen years. Her specialty is biology/living environment and she also served as an administrator for two years. She has continuously taught in culturally diverse high school settings. She is also a trained Chiropractor and practiced medicine for several years before entering the Education Industry.

Mr. H (number five) is an African American, second-year TESOL (Teaching English as a second language)-trained science teacher. For the school year 2015-2016, he served as a co-teacher in a living environment class and provided support to the English Language Learners in the class.

Finally, Ms. AZ, who is Jewish-Caucasian American, is a third-year science and special education teacher. Her major in college was Chemistry and after graduation, she joined the Teach for America program and has taught chemistry, living environment, advanced placement biology, and algebra to general and special education students.

In relation to how familiar educators were about the existence of the learning progression framework for teaching, only one (Ms. MP) was knowledgeable about the existence of this framework. She said she was “…only recently familiar with learning progressions. They make sense.” Ms. JM intimated that she was unfamiliar with the term. In her own words: “I’ve never really heard the term,” while Ms. CL stated, “I don’t really know what a learning progression is.” The same held true for Ms. FB, who said, “I don’t think I’m familiar with it,” a sentiment echoed by Ms. AZ, “I haven’t heard of it.” Mr. H delved right into trying to define what the term means using his prior knowledge and teaching experiences: “A learning progression
is…basically…determining where a student is, background knowledge, anything of that nature…” Although a solid attempt was made, it was apparent that he did not possess a textbook definition and most likely, had heard the term in passing.

All interviewees attempted to define the elements of the LP framework. Not surprisingly, the closest to the textbook definition came from Ms. MP: “it’s a concept that gets increasingly more complex over…a time period,” which came close to Shea and Duncan’s (2013) description of a learning progression as “a theoretical model of how learners develop expertise in a domain over extended periods of time.” Ms. JM’s definition was: “…what it seems like to me is that you’re learning in stages.” This statement in indeed an important component surrounding the theory behind learning progressions and how a sequence of lessons should be constructed. She went on to describe a little more of her thoughts by saying, “…expectations…by the end of the first grade…progress with that stage into second grade…build upon…into third grade.” While she was unfamiliar with the formal term, science learning progression, she correctly postulated that the framework refers to gradually building knowledge year after year, grade after grade, in the classroom.

Others were not as successful or cogent in their attempts to articulate the definition. Ms. CL talked about how content is presented by saying, “…it is the way you structure lessons…so there is a(n) organized, systematic way that you’re going through content and presenting it to students.” While this makes sense with regard to lesson planning, it is an incomplete definition of SLP theory. Ms. FB used her expertise to define the term stating, “…identifying benchmarks over a period of time and trying to hit those benchmarks as you move along that continuum.” This is a stronger definition since she mentions ‘benchmarks’ which can be used as assessment
points in the sequence of a SLP as well as progressing along a ‘continuum’ which suggests a continuous learning process, also true of the SLP.

Mr. H simply stated that a SLP could be “…progress from point A to point Z,” and Ms. AZ stated that it is, “…in terms of some things building on each other…you have to explore…explain and then…ask…the question.” These two teachers attempted to break down the term itself and define it contextually through the use of prior experiences. They presented a more intelligible and coherent response to what the concepts and principles of a SLP represent.

When asked about using this type of framework to guide pedagogy for all types of learners including special education students and English Language Learners (ELLs), Ms. JM believed it would be possible but might present challenges to students who are new transplants to the United States. “…Yes, I think it can used for all…learning levels. The only caveat I see is that somebody who’s new to our country may not have been in that progression and there’s some catch-up to do,” she states. She also strongly believed that younger students may be able to handle a new language and education process more easily than an older student, “because developmentally they’re able to move to the next level…quicker.” Ms. CL held a similar belief, “I think it would probably be better suited to students who aren’t in the English Language Learner category.”

Mr. H further described why ELLs would have a tougher time than other students: “…a student from (the) Dominican Republic…ask about a volcano in Africa…he won’t know that background knowledge…with ELLs I would use a lot of pictures…so they could have visualizations…” Ms. AZ mentioned the difficulty special education students would face saying, “…obviously you have to scaffold…you don’t want to confuse them further.” Eluding to the fact that many special education students have cognitive challenges that can be arduous to
overcome, they would require sufficient differentiation of such lessons to succeed. The AP, Ms. FB and the science coach, Ms. MP both wholeheartedly believed that the framework would be successful if used. Ms. FB states, “…I think it’s relevant especially in science…to all students regardless of their socioeconomic backgrounds,” while Ms. MP states, “…not doing it that way wouldn’t…make much sense…regardless of whether students are learning English…or what…they have types of learning difficulties…scaffolding of concepts and skills…makes information…more accessible to students who might have barriers to learning…”

Should this LP framework be used to plan for the current student population? Teachers expressed concern when asked this question. Ms. JM believed that students in early grades just don’t receive proper training because teachers are less knowledgeable about complex scientific concepts. She stated “…actually I heard in elementary school that kids don’t get a good science background,” because “…most of the teachers are not really that comfortable with science.”

Yilmaz-Tuzun (2008) addressed this comment directly through a study of elementary pre-service teachers’ beliefs and demonstrated that science method courses should focus on building conceptual knowledge in chemistry and physics especially which will build confidence in the classroom, and pre-service teachers who received more science courses felt more comfortable teaching science content. Conversely, Ms. JM also believed that it depends on the history of the student’s upbringing. In her words, “…I don’t think it’s really about the IEP of the student. I think it’s about the history of the students an again when we talk about ELLs, it really depends.” She explained further saying “a Spanish-speaker who came from Spain has a totally different educational system than a Spanish-speaker who maybe from…we have one here from Honduras and (he/she) never went to school versus Puerto Rico, which pretty much has a system like the United States.”
Ms. CL thought that students need a proper academic foundation before they can be successful using this framework: “…it’s not directly applicable until they have more of a foundation for their scientific skills, math skills, reading skill…” Ms. FB expressed similar concerns: “…I really think that if there are formalized benchmarks within the school here, students are going to struggle to get to those benchmarks…I anticipate…more students will fail…because they struggle.” Mr. H and Ms. AZ referenced the issues students with disabilities and ELLs may face in trying to adapt to a new framework. Mr. H stated: “…you have such a disparity…between what the ELLs have, special ed. students have…(and what is)…required to get the information,” and Ms. AZ stated: “…it could have a positive impact…my self-contained students…we have a lot of students who can’t read…or they’re ESL…anything could have an impact…” Finally, Ms. MP believed that using this framework would be tremendous for teachers to plan lessons if they teach similar content: “…in my mind, within a particular school, if there are multiple science courses within different grade levels, the learning progressions would be really useful in vertical planning for science teams…teachers who teach similar content.”

In addressing the use of a SLP to teach students content for the high stakes assessment at the end of the course, most chose to respond directly about the high stakes test itself, versus responding to the actual question asked. Both Ms. JM and Ms. AZ had very similar opinions of the test. Ms. JM stated “I know it’s a high stakes assessment but I don’t think it’s a high cognitive assessment…” and Ms. AZ stated “the regents is not to test how well you know science. This is a test of how well you understand question style…it’s awful.”

Ms. CL, Mr. H, and Ms. FB expressed more cautious optimism with Ms. CL stating “we could start to incorporate it…it would have to be…slowly easing into the science learning progression…to…present the concepts…to students,” and Mr. H saying “yes I do think it can be
used but I also think it can be very difficult.” Finally Ms. FB said “…I know we’re in a revolution where education is concerned, with rigor and the learning...to discover...but...we need to incorporate all these new learning strategies and all these new initiatives (in) preparing kids thoroughly for this exam. Ms. MP simply said “yes” to the question and had nothing else to add to her response.

**Concerning familiarity and the use of multicultural education in the science classroom.** A series of questions were asked regarding if and how these educators were taught in the art of using culturally relevant elements in their profession. There was some consensus as well as some differing responses. When asked about her exposure to multicultural education and training opportunities, Ms. JM recalled having very little during her career. Her response was “I actually have not...not multicultural in the science classroom...I remember taking a class on multicultural learning...” Ms. CL had a similar experience saying “multiculturalism wasn’t really a thing in any of the classes I took...everything I’ve learned...has been on-the-job...listening, talking to students.”

Fortunately, the other four participants did receive some level of multicultural training. Ms. FB stated that “…it has come up when...I was doing the Masters in ESL. We were talking about respecting different cultures and being...aware that you don’t misinterpret signals from different cultural groups.” Ms. AZ, who was also enrolled in a bilingual program, was exposed to multicultural coursework and stated “my advisor...she did a lot of things with bilingual education...and multicultural...I’m still learning with my students...” Mr. H remembers being well trained in this area: “there have been many strategies I’ve been taught to incorporate multicultural education in the classroom...some would argue culture has no place in the classroom. My philosophy is the opposite.” Recall that Mr. H is also a TESOL-trained educator
and was enrolled in a program that trains teachers on how to manage students who speak different languages. Ms. MP took on multicultural learning as a personal challenge, “I...developed...so many strategies just from Googling and looking at YouTube. I came across some really...cool thinkers who gave me...more insight and...more ideas for how to work with students in urban settings particularly in science.”

The educators were questioned about the emphasis and awareness of teachers and administrators regarding their diverse student population and how they plan curricula while being cognizant of potential cultural clashes. Ms. JM, surprisingly, does not associate a connection between diverse cultural settings and student success in the science classroom. She said “I think that particularly in high-needs schools across New York City that the success of learning or...lack of success is not...a condition of the multicultural...student population.” To clarify, she used examples of non-marginalized students coming from cultures other than Black and Hispanic to explain her thoughts. “I’ve seen Punjabi, Cantonese, Vietnamese, and yet these kids are scoring high...and they’re coming from different cultures...” Ms. JM truly believed that student success depends mostly on nurturing that comes from the home setting, which in turn, helps to stimulate a child’s intrinsic motivation to learn. She stated “…no matter where we come from is...how supported are we both at school and at home and what is the internal motivation of a child.” Hers was the only divergent response, as all other educators believe that a high level of cultural awareness is critical for students.

According to Ms. CL “it’s incredibly important to be cognizant of it because it shows the teacher cares about who...students are and students respond better.” Ms. MP had a similar response, “knowledge of students is really...important particularly in science... (there are) misconceptions on the part of everyone...not just sub-groups of people.” Ms. FB and Mr. H
both answered from an administrative lens respectively saying “if you worked in New York City, you’d be crazy not to consider it and not make more than an effort to know the students who are sitting in front of you,” and “…if you are able to incorporate it into a curriculum, into planning…it’s going to have a hook for that specific student and engage them enough to learn.” Ms. AZ related cultural knowledge to students’ vocabulary levels. She stated “if you’re not aware that students aren’t coming with the same level of vocabulary, the same exposure…they are not going to be able to relate…we have to stop to translate the hard words, but not realizing which words are going to be hard for them.”

Finally, educators were asked for possible theoretical examples of a lesson or task that incorporates culturally relevant elements. Ms. JM said that using historical links to scientists, teaching about their cultures and backgrounds and how they contributed to the field is one way of making cultural connections in the classroom. While her suggestion is sound, issues exist because she uses examples of Eurocentric, Caucasian scientists who are not readily relatable to the diverse student population of an urban public high school in the South Bronx. One statement she makes is: “…there’s certain areas of maybe celebrating people who have contributed to that science…” Her examples are “…Madame Curie…or Charles Darwin…their cultural background or…what they did.” While the idea of using the historical background of a scientist to introduce cultural relevance into a lesson would most certainly be effective, one must be conscious of the examples used. A more appropriate and relatable example would be George Washington Carver, Botanist, who was a prominent African American Scientist or Neil DeGrasse Tyson, Astrophysicist who is widely known and revered and who also attended a New York City public high school.
Ms. CL postulated using an example of a non-Governmental organization located in a West African country, which is where many of her students hail from, and having students complete projects on the topic. She specifically suggested a clean water project, “how they clean water…that’s…working to try and improve the lives of the people there and…the science behind (it)…it’s cool for living environment and chemistry.” Ms. AZ also used a chemistry example: “so the other day, during the lesson…I thought about (this) like off the top of my head…we were talking about how metals are ductile…I was like: ‘does anyone have earbuds?’ We talked about the metals in the earbuds and nonmetals around it…they were all excited because they all had them in their pockets…”

Mr. H mentioned a sensitive and somewhat controversial topic regarding cultural acceptances and beliefs around incest; “incest is not frowned upon in all cultures. So if I was doing a lesson in genes, I would want to be…cautious not to look down or to make it look like I am…condemning that lifestyle which is a culture…then going further (in) to that lesson saying how this can cause this types of diseases and these types of issues.” It is important to note here that Mr. H used this as a simple example of a possible topic and he does not in any way tolerate or promote this behavior. Ms. FB used the literacy approach as an English teacher and discussed an observation she made during a visit to another teacher’s class: “this teacher…teaching this text set in the DR…and the kids are on fire! Because most of our kids are Latino…they love it…suddenly…the classroom now becomes yours…it’s a completely different reality when kids can make that connection with (text)…to what they’re doing.” Finally, Ms. MP used a wonderful example of using music to teach scientific concepts: “after watching a YouTube video of a science teacher from Maryland…where he took songs…students will hear on the radio…he will get the instrumental track…and replace it with the science content that reinforces
vocabulary…I started using them and sharing them with other people and just seeing the students in classrooms, just the initial look on their face when they hear the beginning of the song.”

Students first think it’s strange that the teacher is playing this song, and then the actual words come on, and its science content in the lyrics. (see quotes in Appendix C).

**Emergent themes.** After analyzing the data collected from science educators, themes became visible referencing the use of both science learning progressions and multicultural or culturally relevant pedagogy in urban high school science classrooms. (see Figures 4.1 and 4.2).

**Most educators were unfamiliar with science learning progressions.** As stated above, almost all interviewees had not heard this terminology as applied to a teaching framework before this meeting. Only one, the science coach, who can also be highly commended for seeking out new frameworks and strategies in science on her own, was familiar with the concepts behind a science learning progression framework.

**Most educators welcome the use of a new framework, but with stipulations.** In education and teaching, the application of new strategies is continuous and never-ending. Administrators and those outside the classroom would readily welcome the use of a SLP as a potentially novel approach in the hopes that a new game plan would enhance student outcomes. Practitioners, on the other hand, take a more cautious approach. While the idea of a new framework is a possible consideration, they stress the issues surrounding ELLs and students with special needs. These students would require additional resources if they are to be successful. Therefore, teachers employing new strategies would need ample training and professional development, ample planning time with co-workers, and modeling of differentiated lessons from experts to ensure the shifts in the classroom are carried out properly and are indeed successful.
Science teachers are adamant that this is the only way to introduce new methods into the student population.

*Educators were skeptical but hopeful that a new pedagogical framework could improve outcomes in the New York State high stakes assessment.* In most New York City high schools, students must sit for the Regents examinations at the end of core courses in science, math, English, and social studies. The participants interviewed here believe that while this policy does exist, the test itself is not an accurate measure of students’ knowledge or intelligence. That is, the test lacks depth of knowledge and is written at a cognitively lower level. Two teachers outright stated that the test is “awful” and “not high cognitive”, completely deflecting the question regarding the use of a SLP to teach the curriculum but certainly implying the use of a SLP would not make much difference. Two others expressed better confidence in the use of a SLP provided that implementation is slow and fair. Both non-practitioners believe the use of a SLP would indeed help students succeed by providing more strategies to help them learn.
**Science Learning Progressions**

*Most educators were unfamiliar with science learning progressions*

“I’ve never really heard the term…”
“I don’t really know what a learning progression is…”
“I don’t think I’m familiar with it…”

*Most educators welcome the use of a new framework, but with stipulations*

“Yes I think it can be used… somebody who is new to our country…there’s some catch-up to do.”
“…with ELLs I would use a lot of pictures…”
“…you have to scaffold…you don’t want to confuse them further.” (In reference to special education students)

*Educators were skeptical but hopeful that a new pedagogical framework could improve outcomes in the New York State high stakes assessment*

“The regents is not to test how well you know science. This is a test of how well you know question style.”
“We could start to incorporate it…slowly easing into the science learning progression…”
“We need to incorporate all these new learning strategies and all these new initiatives (in) preparing kids thoroughly for this exam.”

*Figure 4.2*: Emergent themes regarding learning progressions and science learning progressions with sample quotations from interviewees. Themes describe educators’ unfamiliarity with SLPs as an instructional framework, but they are open to utilizing the framework if implemented with students’ abilities in mind. Educators believe that new approaches can benefit students through progressive strategies.

**Pre-service and in-service training fails to prepare science educators to practice in culturally-diverse student settings.** One of the more unfortunate revelations of this study is that even in the 21st century, teacher education programs are failing new teachers and by extension, failing culturally diverse students when they do not adequately educate new teachers about being culturally cognizant in the classroom. In science education programs experienced by interviewees, this type of training was sparse or completely absent.

*ESL and Bilingual programs do provide multicultural education training.* Of all participants, only those who were enrolled in ESL or bilingual programs were purposefully
exposed to multicultural training. In many respects, multicultural education provides a foundation for an ESL/bilingual program obviously because educators are being trained to handle students who come from different countries, different cultures, and speak different languages. Teachers learn a multitude of strategies that they can employ in culturally-diverse classrooms. These teachers did not hesitate when asked about how they would incorporate elements of CRP into their everyday lessons since this is how they have been teaching since the beginning of their careers. Unfortunately, it is exactly this type of training that is deficient in science teacher education training programs.

_All but one educator understands the importance of being cognizant of diverse cultural backgrounds when creating lessons._ Only one teacher wholeheartedly believes that a student’s culture is not tied to his/her academic successes but instead is directly correlated to that student’s education foundation and support from parents/guardians. All others are acutely aware that when students are thrown into settings that are completely foreign to them, teachers need to be sensitive to these changes and work with students to transcend challenges and become successful in the classroom. Students are people who become academically and emotionally invested in school, therefore if they believe their teachers truly care about them and are making efforts to understand them, these students will tend to move along the correct path more easily.

_Educators can create culturally relevant science lessons._ The goal of the last interview question was to put educators through a little discomfort by asking them to come up with a lesson that contains culturally relevant elements on the fly. Remarkably, all were able to quickly think of ideas for future lessons or use examples of instances in the classroom where they or another teacher was able to forge a connection with students through the use of a familiar artifact. The success of these responses demonstrate an awareness, even if previously unnoticed,
that these education stakeholders have become familiar with their culturally diverse students and have been making efforts to accommodate and incorporate their cultures into science lessons.

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**Figure 4.3:** Emergent themes regarding culturally relevant pedagogy and multicultural education with sample quotations from interviewees. Themes describe the lack of formal multicultural education training, except for ESL, and bilingual-trained educators. They believe that knowledge of students’ cultural backgrounds is vital when planning lessons and educators are highly capable of integrating elements of CRP in their lessons.

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Culturally Relevant Pedagogy/ Multicultural Education

**Pre-service and in-service training fails to prepare science educators to practice in culturally-diverse student setting**

“I actually have not…not multicultural in the science classroom.”
“Multiculturalism wasn’t really a thing in any of the classes I took.”
“…not a formal course…”

**ESL and Bilingual programs do provide multicultural education training**

“It has come up when I was doing the Masters in ESL. We were talking about respecting different cultures…”
“That was a pretty big chunk of what we learned…how to take multicultural learning and implementation in the classrooms.”
“My advisor…she did a lot of things with bilingual education…and with multicultural…”

**All but one educator understands the importance of being cognizant of diverse cultural backgrounds when creating lessons**

“It’s incredible important to be cognizant of it because it shows the teacher cares about who…students are and students respond better…”
“We need to…try to bring more of their culture as is relevant inside our lessons.”
“If you really just took diversity as true and capitalize on the idea that everyone has a different background…it breaks barriers between students and gives them a better learning environment…”

**Educators can create culturally relevant science lessons**

“…there’s certain areas of maybe celebrating people who have contributed to that science.”
“After watching a YouTube video of a science teacher…where he took songs…and replace it with science content.”
“…we were talking about how metals are ductile…I was like: ‘Does anyone have earbuds?’…we talked about…the metals in the earbuds and the nonmetals around it.”

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Research Question 2: How through professional development do we integrate Culturally Relevant Pedagogy with parts of a Science Learning Progression for teacher learning?

Recall that even though I interviewed six education stakeholders, I was granted permission to carry out observations with only one teacher participant (Ms. AZ), and she was also the only participant who agreed to participate in professional development sessions. At the onset of this study, conversations with the research participant teacher led to a series of four semi-formal professional development sessions where she was introduced to the theoretical concepts behind science learning progressions and culturally relevant pedagogy. To accomplish this, I used handouts, peer-reviewed journal articles, standards-based documents such as the Next Generation Science Standards and the New Visions Curriculum for Living Environment. She was also informed using a PowerPoint presentation that I created using literature and background information. We had extensive discussions where she could ask questions and clarify her role in the study. Together, we adapted a portion of school’s prescribed Living Environment curriculum, inserting formalized elements of culturally relevant pedagogy. Fortunately, her own educational experiences had already introduced her to many components of being a culturally relevant teacher as had her actual experiences teaching in an urban public high school in the Bronx. It was also immediately noted that the prescribed curriculum, the New Visions Living Environment curriculum, has been written in a science learning progression format. According to Joyce and Calhoun (2015), providing professional development sessions to adequately cover the Common Core State Standards as well as for science, technology, engineering, and mathematics (STEM) can be a challenge, thus it is advantageous that the prescribed curriculum is already fully aligned to the New York State Standards and the Common Core Learning Standards, which has been adapted by New York State.
We had informal meetings four times before I began classroom observations, then she introduced me to the students in the class where I took time to discuss the study with them, allowing them to ask questions and getting written permission from them, before sending out consent requests to their parents and guardians. It should be noted here that Ms. AZ had full discretion to choose a classroom for the study. The set of students that she ultimately chose demonstrated a more well-behaved environment where she intrinsically believed that she could enact this SLP-CRP unit successfully, without excessive push-back from her students. She exhibited a measure of teacher bias in choosing one of her better classrooms for this study. My reported observations and emergent themes will show an improvement in the overall learning environment, but these students began with a moderate level of positive behavior.

During the periods in which I visited the science classroom, which were taught by her, Ms. AZ utilized a version of the New Visions curriculum for Living Environment, which she had easily located and modified for her specific students. Contrastingly she used a more traditional, teacher-centered approach to pedagogy in other classrooms receiving only instruction, but students were taught the same concepts. As a Renewal high school, the staff were provided with additional personnel to coach and assist teachers with curriculum and lesson planning objectives. One of these coaches suggested the use of the New Visions curriculum as it had been successfully adopted and implemented in other Renewal high schools.

While planning, Ms. AZ took several factors into consideration, including the students’ background knowledge, past educational experiences, reading levels, mathematics levels, and cultural backgrounds. Records of middle school grades, examination reports, as well as mathematics and reading levels are standard sets of information provided to high schools and readily available for teachers to refer to. Being cognizant of factors such as these demonstrates
the teacher’s ability to account for students’ personal experiences and the multicultural settings that many come from.

How effective can professional development be in changing the landscape of in-service teacher education and mindset? Here, professional development refers primarily to extended training offered to individuals who are already teaching and not to student teachers or pre-service teachers. In one study reported by Van Der Klink et al. (2016), teachers interviewed mentioned several factors that were of concern to them and their professional development. Namely, linking the theoretical aspects of PD with actual practice, ensuring their students feel empowered, self-reflection of practice, and maintaining an overall high quality of pedagogy. While a lack of time was noted in almost all participants in this study, it is worth mentioning that interest in pursuing PD was largely intrinsic, especially since many participants received little to no support from superiors. For PD to be effective, teachers must achieve deeper levels of understanding of materials and concepts being presented in order to sustain practices in the classroom (Baker et al., 2004).

Similarly, Steeg and Lambson (2015) discussed the significance of collaboration among teachers coupled with purposeful use of teacher ideas and feedback as related to their own learning process. Therefore, the attitudes and beliefs that teachers bring to and leave with at training sessions are directly correlated with use of new strategies presented (King, 2014). Another study reported by Avidov-Ungar (2016) discussed how teachers perceived their PD requirements, essentially noting that while all teachers in the study felt that PD was an important part of continual growth and enhancement, motivations differed between them. A larger portion saw PD opportunities as a method of self-improvement, while the rest only took these opportunities seriously because superiors constantly monitored their performance. Some
teachers also used PD as a method of progressing in an upward manner, and others saw PD as a way to improve performance laterally. Notably, there is little empirical data to support how professional development can drive implementation of science content that has been reorganized in newly enhanced curricula materials (Penuel et al., 2014).

In regard to the cultural nature of specific student populations and the teachers who instruct them, there is a continuing need to train pre-service and in-service teachers to render them culturally responsive (Mensah, 2011). According to Banks and McGee (2004), when one is able to increase awareness of one’s own self-identity and also increase awareness of the characteristics of diverse groups, one is said to be culturally competent.

Ms. AZ, the teacher participant in this study was trained informally in the use of a culturally relevant science learning progression unit to be implemented in one of her classrooms. Our initial sessions of approximately twenty to thirty minutes each introduced her to the conceptual framework of science learning progressions and to the elements of culturally relevant teaching. Using available literature, I compiled a training presentation Power Point that easily outlined the major tenets of science learning progressions, provided a few examples of what these would look like, and finally, I included aspects of culturally relevant teaching, which she would have to be intentional about in her lesson planning and implementation. After initial exposure to the frameworks and full understanding of the study’s intent, we worked collaboratively on lesson planning for the reproduction unit of the Living Environment course. At the end of this process, Ms. AZ completed a questionnaire intended to provide me with information regarding her impressions of these frameworks and their usability. Her responses are described below in detail.
The initial question asked her to describe her own definitions and understandings of the science LP as she now understood it. She said “science learning progressions allow science teachers to expand student understanding and thinking about science by moving them towards gradually more complex concepts.” Secondly, she was asked to suggest a possible lesson sequence using this framework. The big idea lesson she used was homeostasis, which “…keeps our body regulated and prevents disease.” The essential question would be, “how do hormones keep our body in homeostasis?” One student task suggested would be for students to create a flow chart of how the body regulates blood sugar levels. This interesting topic is also made culturally relevant by using familial examples where students share experiences they’ve had with members of their own families suffering from diabetes or other hormone-based disease.

The next question asked about her likeliness of using a science LP versus the traditional lesson. She said, “very likely as it allows me to go in more depth rather than breath.” This statement is an echo of responses heard previously describing the sheer length of New York State’s Core Curriculum, which contains many performance indicators, but lacks a depth of understanding and cognizance that is necessary to construct knowledge. The fourth question centered on whether she believed such a framework would change the way students learn science and why. She reiterated that “students will have a deeper understanding rather than memorization of the facts,” allowing them to create connections, and new knowledge instead of simply recalling low-level information.

The fifth question asked for her professional opinion of the training session and how the presentation could be further improved to encourage usage by teachers. Ms. AZ did not hold back with her suggestions to this question. She suggested the inclusion of real examples, namely lessons that have been taught previously. Additionally, a “description of struggle” should be
used because professional development sessions “…always talks about good things but that’s not realistic. Also want to hear limitations.” In her experiences as a teacher, most PD training workshops provide mainly positive situations and examples however, teachers must also be shown where these strategies can be unsuccessful in the classroom. This is also a great place to grow in your profession as it presents opportunities to troubleshoot a problem, collaborate with other teachers at the training, and create solutions that can be used in a multitude of locations. Finally, she suggested that pre-made lessons be provided for teacher use as a template moving forward. Here, teacher motivation plays a significant role in the likelihood of using the information from these sessions. Motivational levels will naturally increase when a presenter brings a concrete example to distribute and share with session participants. She specifically says “…pre-made lessons so you can try it rather than (it) just being a concept.” It is often forgotten that teachers bear heavy workloads even without additional trainings and mandatory meetings. Therefore, a PD presenter will be highly appreciated for providing an actual lesson to teachers for use. For this study, the teacher and I collaborated to create culturally relevant lessons.

The next question focused on the understanding of multiculturalism and culturally relevant teaching. Her response was “culturally relevant education is that (you) make sure your examples (are) relatable. Students in the city have most likely never been white-water rafting so don’t discuss this as an example.” Her reference to white water rafting served to demonstrate the differences in cultural upbringing of students in her classroom versus students living in a more rural area or Upstate New York where the opportunity for a white-water rafting expedition is much greater. She is very cognizant of these cultural differences between herself and her students, and consciously writes lessons to address these differences. Importantly, Ms. AZ was
trained in a Special Education concentration in graduate school and has therefore taken several courses that were written to include strategies for students from multicultural backgrounds.

Question seven asked about her confidence in utilizing a science lesson with elements of culturally relevant pedagogy in her classroom and how it’s success could be measured without using test results. Her response was “I love it, I’ll use it, because it’s great. I will use student discussions, examples from their own backgrounds, written responses, and visual presentations.” Here she alluded to tactics already employed in her daily lessons where students are assessed without the need for a formative exam. In her class, students would be given points based on responses to questions, discussions, completion of assigned written activities, participation in classroom conversations, and other formats completed during class. When asked about a possible topic in science that would be culturally relevant for her students, she immediately suggested sickle cell anemia, as this is a disease that students are very familiar with. Some students either have the trait, or someone in their family or otherwise has the disease. The disease also predominantly affects Blacks in the United States.

When asked if integrating elements of CRP into the science LP sequences would change the way diverse students learn science, she said “yes, more investment and interest in the curriculum.” Students in urban high school settings such as hers are bombarded with outside factors that affect their motivations to learn. If the lessons being taught are not relatable and they view them as uninteresting or boring, students will be completed unmotivated and uninspired to learn. Through the intentional use of their cultural backgrounds and experiences integrated into lessons, students can now own the classroom and feel as though the material has become a part of their lives. The last question asked about making this process better and more encouraging to use in the classroom. Ms. AZ repeated the information given in question number five, where
using real examples, describing the struggles of the strategy, and providing a concrete lesson would be the most effective method to convince teachers to buy in.

Appendices E and J shows samples of the reproduction unit and her unit plan, which Ms. AZ and I worked on where we utilized the New Visions unit, modifying the content to better fit the needs of the students in her classes. We also adapted elements of Culturally Relevant Pedagogy, inserting these into the science unit as a reminder when planning lessons. Ms. AZ successfully followed the three CRP assertions mentioned in that she was able to collaborate with other teachers from different cultural backgrounds in her school and through her graduate education program, and also with me to gain knowledge and insight into different cultures.

Discussions around relevant strategies for teaching students from diverse cultures resonated with her and she employed these strategies in her planning and pedagogy. The second assertion, where indigenous language is the focus was achieved through experiences through her years in the classroom and outside encounters with students during other school activities. She developed a working knowledge of students’ ways of speaking through consistent interactions with them and their peers and their family members during parent-teacher conferences and other events that parents attended. She did not develop a relationship with students outside the school setting.

After several intimate and semi-informal conversations with Ms. AZ, I can state that she has absolute love for the science discipline and has held on to her science beliefs for many years. She is fully confident and comfortable with science content and completely understands that students in urban school settings need the opportunities to build conceptual knowledge of science through authentic, hands-on learning experiences.

**Research question 3: What does the use of a science learning progression integrated with elements of culturally relevant pedagogy look like in a science classroom?**
Over the course of one semester, I observed two living environment/biology classrooms at an urban public high school in the Bronx. The same teacher (Ms. AZ), who also taught Advanced Placement biology and chemistry in addition to these two classes, taught the classes observed. While students in the Advanced Placement classes and Chemistry classes were selected based on previous successes in other classes, students enrolled in the biology (living environment) classroom were equally distributed with no selection criteria used to place them in these classes. Also noteworthy is the fact that the teacher is a certified chemistry teacher with a special education extension license. Both classes were made up of general education students and students with Individualized Education Plans (IEPs)/special education students. Both classes were ninth grade level and the main purpose of the course was to prepare students to take the high-stakes living environment regents examination at the end of the school year, which they are required to pass in order to graduate from high school as per the school’s policies. In terms of literacy/learning levels, students ranged from being able to read and write at the fifth-grade level to the ninth-grade level (this information was obtained from the school’s records of eight grade scores) and were also equally distributed into these two biology classrooms.

As the individual who had been with these students since the beginning of the school year, Ms. AZ suggested which class would receive the SLP-CRP model unit. In the SLP-CRP classroom, students sat mostly in groups (except for one or two outliers) and were encouraged to complete readings, questions, and other activities in these group settings. These students were very aware of class routines and seating allocations and were given more accountability for learning scientific concepts. In the classroom, the teacher utilized a very effective point system where participants were encouraged to answer frequently, gaining more points as they participated and were able to see their progress displayed in real time. The teacher participant
adapted the New Visions living environment curriculum, making use of the numerous activities, reading material, and other strategies readily available from using this curriculum.

**The New Visions living environment curriculum**

According to the website’s home page, the New Visions living environment curriculum is a project in its pilot stage and is being funded by the Noyce Foundation, JP Morgan Chase Foundation, Toyota USA Foundation, and the Bill and Melinda Gates Foundation (New Visions for Public Schools, 2017). The living environment sequence has been aligned to both the Common Core Learning Standards and the New York State Living Environment Core Curriculum, encompassing roughly nine units of study that covers one year and relying on students’ prior knowledge in science and biology for success in high school level coursework. New York State does not currently require K-12 schools to align science curricula to the Next Generation Science Standards (NGSS), but the New Visions Curriculum has included strategies and activities that are aligned to science and engineering practices and cross cutting concepts from NGSS.

While not explicitly stated, I argue that the New Visions living environment curriculum has been written using an adapted science learning progression conceptual framework, since the learning objectives align with many elements of the science learning progression framework. According to Cocoran, Mosher, and Rogat (2009), science learning progressions should have the following elements: 1. Learning goals, which represent the end point of the progression and defined by societal needs, analysis of the field, and enough knowledge to lead to the next level; 2. Variables that track progress over time such as core concepts; 3. Achievements measured in intermediate steps; 4. Performance tasks, which represent measures of students’ learning and can be used to develop assessments; and 5. Assessments, both formative and summative and created
using different strategies to meet the needs to different learning styles. All elements listed are indeed found in the New Visions curriculum. New Visions has used research materials in science and science education as well as existing practices that have proved successful in high school settings to compose their sequence for the living environment course. Along with this literature, the organization works closely with science teachers and content experts, relying on their specialized input to ensure the curriculum is rigorous and challenging (New Visions for Public Schools, 2017).

This curriculum, while used to prepare students for the living environment regents, is different from the traditional curriculum, the New York State Core Curriculum. For one, this biology sequence has incorporated an array of activities, for individual and group settings, as well as numerous pieces of literature accompanied by analysis tasks, questions, modeling activities, and laboratory activities. It therefore adds a layer of complexity and rigor to the pre-existing New York State Core Curriculum, which consists of a copious number of standards and performance indicators, many of which are at a basic recall level. While the major topics covered are the same as the New York State Core Curriculum, New Visions focuses on depth of knowledge, guiding teachers to create units that encourage student-centered learning and deeper thinking and application of concepts. To begin with, educators are provided with a curriculum map, which describes a summary of the units and includes suggestions for pacing and spiraling of content. In addition to the many opportunities for reading, writing, and analyzing text, the New Visions curriculum proposes inquiry-based instruction in the form of experimentation coupled with writing and explaining scientific observations.

A major component of this curriculum is the use of the 5E instructional model for teaching units in the science classroom. This model can be traced back to an early 20th century
Philosopher, Johann Herbart, who believed that students can learn by using their prior knowledge and applying it into new ideas eventually creating new concepts. The steps involved allow students to discover an idea before being taught or introduced to the formalized concept by the teacher (Bybee et al., 2006). The steps of the 5E model are engage, explore, explain, elaborate, evaluate. At the end of each cycle, students would have had a chance to use inquiry-based learning, group activities, gradually more complex questions, textual references, and dispel misconceptions. Students are also assessed throughout the unit using traditional methods like quizzes, but also including writing assignments, and group discussion rubrics.

Over approximately three months, I observed the teacher participant using the adapted New Visions curriculum while she taught the reproduction unit in two living environment classrooms. Ms. AZ adapted the unit by incorporating literature and activities she had created specifically for her students, eliminating some of the text and activities from the New Visions unit plan. She used the same pacing and sequence of topics suggested by New Visions. She also created her own formative assessments for determining students’ understanding. She was instructed to incorporate culturally relevant pedagogical elements into one classroom, while continuing to teach in her traditional mode in the second classroom. It is important to note here that in many instances, she used examples of culturally relevant teaching in both classrooms, but unknowingly and more organically in the second classroom, while the use of CRP in the experimental classroom was premeditated and intentional. While the focus of this study is not a comparative analysis of the implementation of units in these classrooms, I will show some examples of the observations noted in each classroom.

A major goal of this study has been to identify instances of enhanced learning and conceptual knowledge building in the science classroom as a result of the teacher’s increased
awareness and expression of students’ cultural backgrounds. This can include the use of specific language relatable to students, use of examples or objects which students can intimately relate to, having conversations that are more directly related to students’ personal experiences and not only academic-based discussions, and the presence of a warm and respectable learning environment where students are comfortable speaking and expressing themselves honestly, without fear of negative repercussions. Results from observations and recordings are reported below.

Concerning the use of an adapted science learning progression with elements of culturally relevant pedagogical elements incorporated in a biology classroom

Observations and classroom visits were initiated at the very end of the Fall semester of teaching. Students were introduced to me as the researcher and they were allowed to ask questions to clarify exactly what was going to occur while I visited their instructional sessions. In this, the SLP-CRP classroom, the participating teacher would be incorporating nuanced elements of CRP into science lessons adapted and created from the New Visions Living Environment curriculum. Admittedly in January, the teacher-student bonds had already been forged and were observed to be quite strong. Students were highly aware of the teacher’s expectations walking into the classroom and followed instructions when they were given. The ultimate goal of adding CRP would be framed around enhancing these relationships even further.

Emergent Themes. Analysis and coding of classroom observations and transcripts gave rise to several themes encompassing the relationships between the teacher participant and students in the living environment classroom where cultural knowledge of students was intentionally used as a pedagogical resource. It was noted that the level of engagement and the quality of the student-teacher relationships was greatly enhanced with the use of CRP elements.
Observations made in the SLP-CRP classroom regarding the use of CRP

*The teacher is able to carry on respectful and purposeful conversations and discussions with students.* During one lesson, the teacher discussed the possibilities of modifying her instruction to motivate and inspire her students to learn science. She introduced me as the researcher and explained that I would be present during some lessons. She discussed the process of getting a Doctoral degree and the immense effort required to succeed. Students were very interested in the notion that you can create something new during the research study and asked her numerous questions about this aspect. One student thought that it was remarkable that a person getting this degree could actually invent something new. Students lead this informal, respectful and purposeful conversation with the teacher for some time and gained new insight into a possible future academic goal. Many students participated in this conversation with fluid and engaging dispositions. At the end of the conversation, the teacher continued the lesson by ensuring her students were clear on the assignments.

With the exception of a few individuals in the class, the interactions between the teacher and students embodied an atmosphere of purposeful learning and a high level of respect. Ms. AZ embodied a teacher who took the students’ experiences into consideration when carrying on classroom discussions and encouraged them to speak freely and respectfully. Discussions like this were seen in all fourteen sessions visited indicating a substantial level of engagement between the teacher and her students. The lessons progressed through a sequence where students were aware of their task upon entering the room (even when they were late for class) because the teacher projected instructions and placed materials close to the door, and once they completed the initial activity, the interactive mini lesson would begin, and here new concepts would be introduced where students would have many opportunities to ask and answer questions in an
interactive way. Students were motivated to participate in these exercises and discussions were productive. The use of interactive activities and student-centered discussions as outlined by the New Visions SLP unit demonstrated increased levels of student participation.

For example, during a lesson on internal and external fertilization, the teacher was able to elicit correct responses from students by continuous questioning with immediate feedback. Instead of offering the answers, she allowed the students to help one another until they verbalized the correct scientific answers. This embodied the SLP idea of consistently assessing students to check for understanding. In another lesson on meiotic cell division, students worked diligently on the activities assigned while the teacher walked around the room, giving immediate feedback such as telling them they were progressing well and that they were on the right track and assisting when students faced challenges such as unfamiliar vocabulary or inability to complete questions. As students sat in their groups, she facilitated a group discussion to elicit responses on the topic instead of providing them with answers. Those who were hesitant to answer were assisted by their peers and the classroom discourse was completely student-centered. The teacher only provided prompts and students built upon one another’s responses. This represented another level of a SLP where the teacher allowed students to think deeply about the topic and she uses checkpoints to ensure they understand the material. A third lesson on embryonic development had students working collaboratively on an inquiry-based task. Students engaged with one another to complete information while the teacher perambulated the room to ensure they remained on task. By using these strategies, the students were encouraged to think deeply about the questions and ultimately discovered the answers, and were able to self-assess through peer discourse. This strategy, another SLP-type principle, allowed a high level of
student self-assessment where the teacher’s role as facilitator was to ensure accuracy and
clarification of any misconceptions brought up.

A clear set of routines (which become rituals) in the classroom allowed fluidity and
efficiency of tasks. Students were familiar with routines that had been created and practiced at
the beginning of the school year in September. They were cognizant of the sequence of the
lesson, where to locate materials, where to submit materials, and went quickly to assigned seats
when directed by the teacher. They also responded quickly when given directions to do things
such as moving into groups or retrieving computers. For example, during one lesson where the
use of ipads was needed, students immediately provided their student identification cards as
collateral before taking the ipads from the cart. During another lesson on embryonic
development, students quickly moved into groups to work collaboratively on their task. These
routines, while seemingly minute, are vital for creating a classroom where time is essential and
cannot be wasted on mundane tasks like submitting homework or retrieving a handout.

Becker (1963) discussed the uses of positive routines and rituals as effective modes of
curbing otherwise negative behavior, which can be implemented in any high school classroom.
For example, the teacher introduced a valuable strategy at the beginning of the school year by
utilizing simple routines, which students practiced daily until they became experts. To this end,
routines became rituals through practices that were organized and repetitive. In an urban science
classroom, establishing routines and rituals provides space for students to become active
members of a discipline that requires more than writing in notebooks and reading textbooks. A
teacher who successfully establishes routines and rituals will also teach students accountability
for their actions where they utilize discipline when practicing science without the teacher’s direct
oversight. They can be entrusted with the responsibilities of scientific inquiry because of the
proven successes they have demonstrated in the classroom. Ms. AZ successfully created a classroom environment where students from many cultural backgrounds and personal situations felt like their presence was vital to the proper functioning of the classroom. These students were therefore able to curb potentially negative behavior at the beginning of the school year, and progress into a positive, motivational environment with their teacher and peers. Ms. AZ did not limit these practices to only one classroom. Her attempts to introduce routines were made in both classes however, her success was limited in the second classroom as you will read below.

**Student-teacher rapport demonstrated a high level of engagement with the use of CRP.**

In all fourteen lessons visited in class A, students were observed responding positively and actively engaged in the lessons being instructed. The teacher participant successfully enhanced students’ motivational levels through the use of CRP strategies in class A. She used students’ indigenous language modes when it was appropriate. For example, during a lesson on fertilization, the teacher used slang while addressing a concept: “who’s running the show here…if there’s no egg chilling in the fallopian tubes, will the cervix be open? The responses to her questions were immediate and in multiple voices. Students eagerly shot up their hands to answer. A second example was noticed in a lesson on evolution where she made connections to students’ personal experiences. The teacher used several strategies to elicit responses related to the topic then offered a brief explanation about natural selection. She related the concept of variations in species to the students and their family: “Now, in any given population of plants or animals, there are always variations. Look at your family, brothers and sisters; you’ll see what I mean. None of us are exactly the same, except maybe for twins. Some variations…can be passed on to your kids? Here the teacher related a scientific concept directly to the students and their immediate relatives, which students instantaneously recognized and were able to connect to.
The purposeful insertion of CRP into academic discussions through her language and using familiar examples rendered these conversations interesting and more familiar to urban students. Through the use of simple slang words and phrases that students used in their everyday conversations, students recognized the teacher’s attempt at bringing their attention to important information. By intentionally relating a topic to students’ relatives, they immediately believed in the statement’s truthfulness and paid closer attention to the content wanting to know more. The teacher also provided translated materials to students who spoke a language other than English to ensure their continuous participation in the lesson sequence and to maintain a level of equity.

**Utilizing a variety of learning modes and materials significantly differentiates challenging concepts to reach many learning levels.** Through the use of several differing types of activities and assignments, students were given equal and ample opportunities to build conceptual knowledge of traditionally difficult scientific concepts. Students in the ninth grade classrooms enter into high school from various middle school experiences, and some are brand new to the United States, mostly coming from Spanish-speaking countries and islands such as the Dominican Republic and Mexico. In the majority of these instances, students speak very little English, and many have had little to no formal education leading up to the high school level. Thus, it is urgent for teachers in urban public high schools to accommodate such students by providing highly differentiated learning opportunities for learning to occur. The teacher participant in this study provided students with textual materials that were modified for different reading levels and used visual, auditory, and kinesthetic methods of instruction and activities. Students would not only listen to her speak, but they would see pictures and images on a SmartBoard. She would translate the materials into Spanish for those students who struggled with English. This meant that she modified some of the texts provided by the New Visions
curriculum to include different reading levels and she also used text assignments she created.

Classwork would consist of materials and worksheets that contained images and pictures along with questions and vocabulary. Students would be shown videos and documentaries about topics and she provided hands-on activities through laboratory protocols, modeling and classroom assignments. At least once per week students made use of technology in the classroom by being allowed to use ipads to access an interactive science website where they would progress through short modules with images, text, and animations, then answer relevant questions. The teacher kept track of all students through real time updates. Students also had language resources provided by the school to assist new English speakers with the process of learning the language. The co-teacher would help students with classroom work and help students on an individual basis, thus working as a team with the lead teacher. Students also worked in groups of three or four on a daily basis adding a vital layer of discovery learning to their experiences where they were able to work collaboratively with peers and used self-assessment discussion activities to ensure understanding of concepts. To this end, students flourished, were provided with numerous ways of building knowledge, and the classroom dynamic functioned on a very high level.

The use of high-level questioning, positive reinforcement, and facilitation allowed students to discover concepts. Many of the scientific concepts being taught in the biology class have been touched on in middle school science and are being delved into deeper levels in high school. Students may not have vivid, clear memories of such nuanced information, but the information might be contained deep in their memories. The teacher used a very successfully method of questioning in her classroom to help illicit these evasive thoughts, essentially allowing students to inquire and discover answers at a deeper level. Traditional modes of teaching have
consisted of a direct-instructional or transmissive method, where the teacher stands in front of a board and lectures to students in a teacher-centered classroom, while they remain silent and take notes throughout his/her lecture, only speaking if spoken to. While this may work for the intrinsically motivated child, who studies in his/her free time and is able to work through challenging material unaided, this pedagogical method has been extensively reported on and discouraged as the main mode of practice (McGhie-Richmond, Underwood & Jordan, 2007). The teacher instead, used mini lessons to transfer concepts to students, allowed them to speak and ask questions during the lesson, and gave them high-level assignments to work through difficult concepts. While speaking about a topic, she preferred to have students answer the questions that are asked by their classmates and only interjected if she noticed them getting confused or if misconceptions were raised. She skillfully used phrases such as ‘how would you answer that’, and ‘do you agree with that response’, and ‘does anyone want to add anything’, to students’ responses. She served to facilitate the discussion, which were being lead by students and eventually, they discovered the answers, and the teacher confirmed their thoughts. This method not only allowed students to figure out the material themselves, but they expressed and dissolved misconceptions. Students also self-assessed through peer-to-peer discourse where the teacher successfully monitored their progress and mastery of concepts learned. During one activity on embryonic development, students sat in groups with a graphic organizer, and through collaboration, correctly completed the task in a timely manner. In another lesson on the placenta, students discussed information in groups, answering questions together, and participating in a class-wide discussion facilitated by their teacher. Here, students successfully built conceptual understanding through student-centered activities.
Table 4.4: Emergent themes, reactions and responses in the SLP-CRP classroom

<table>
<thead>
<tr>
<th>Emergent Themes</th>
<th>SLP-CRP Classroom</th>
</tr>
</thead>
</table>
| The teacher is able to carry on respectful and purposeful conversations and discussions with students in class A. | • “There is something called external fertilization.”  
• Students respond well to questions  
• Students able to bounce answers off each other |
| A clear set of routines (which become rituals) in the classroom allowed fluidity and efficiency of tasks in class A. | • Students picked up materials upon entering classroom.  
• When prompted to move into groups, they did so immediately.  
• Sequence of the lesson was familiar to them.  
• If teacher deviated, they questioned her reason |
| Student-teacher rapport demonstrated a high level of engagement with the use of CRP in class A. | • Teacher used ‘slang’ in her discussions, increasing level of focus by students.  
• Students felt comfortable knowing their teacher accepted their indigenous mode of language. |
| Utilizing a variety of learning modes and materials significantly differentiates challenging concepts to reach many learning levels. | • Questions, group activities, videos, discussions, writing activities, and more.  
• This resulted in higher levels of engagement and participation.  
• Students did not feel bored during lessons. |
| The use of high-level questioning, positive reinforcement, and facilitation allowed students to discover concepts in class A. | • Teacher used strategies to guide students to the answers instead of giving them the answers. They were successful in many cases. |

**Observations made in the SLP-CRP classroom regarding science instruction**

*The teacher’s use of SLP in the classroom allowed her pedagogy to grow.* In the initial set of classroom visits and observations, Ms. AZ modified her pedagogy to fit into the SLP model. Because she had previously used more traditional teaching methods such as lecturing and having students take notes regularly, implementing the principles of a SLP required a major adjustment to her methods. However, due to the level of respect already established as part of the classroom environment, shifting the overall flow of lessons, while a learning process, went smoothly with the students.
It is noteworthy to remember that while we worked together during PD sessions to incorporate elements of CRP into the SLP unit, we did not create this unit from scratch. This unit was created by the New Visions for Teaching organization and made available to schools such as the one in which my study was carried out. Also note that Ms. AZ was never trained to adapt and implement this framework in her pedagogy nor did she use the exact principles of a SLP to write parts of the unit. She was simply given this ready-made curriculum written in a SLP framework format, which she adapted for her students and successfully utilized it to shift her pedagogy from traditional to more student-centered.

For example, in the beginning of the unit (Reproduction), she introduced the topic to her class by asking them to think about any prior knowledge around similarities and differences between human reproduction and how other species reproduce. Further, how do these similarities and differences help scientists determine evolutionary relationships between species. These questions were answered with short brainstorming sessions where students worked in groups to access prior knowledge, discuss with peers, and record responses on paper. The teacher then introduced major vocabulary, which she explained would be used throughout the unit and they would define as they progressed.

As the unit progressed, Ms. AZ used a variety of resources that were provided by New Visions as well as her own handouts and worksheets. For example, during her lessons on gamete production and fertilization, she began by using a flower dissection lab to engage students by helping them become invested in the science content through a hands-on activity. Students were able to learn about flower reproduction as well as the anatomy of the flower. They connected pollen to sperm and realized that flowers carry out sexual reproduction. Students also addressed some misconceptions such as pollen not being related to sexual reproduction as well as flowers
not being a part of reproduction. In another lesson, students looked at fertilization pathways in different species exploring resources provided to them. Here, the teacher conferred with them, asking questions such as “do you notice any similarities in fertilization across species?” The teacher also facilitated a group activity where students used the information from the resources and questions to complete a graphic organizer, which was them used as the basis for a class discussion. Throughout these lessons, the teacher was reflecting on student learning and making notes to plan forward based on the level of knowledge articulated by students. It is important to note here that if the teacher decided that students had not reached a level of understanding, her next step would be to re-teach the concept in a different way to ensure understanding.

By the next lesson, students had collected enough information about reproduction and fertilization where they could explain their findings to describe internal and external fertilization. At this point, the teacher provided textual information for students to annotate. Students self-assessed using a graphic organizer and peer discussions, while the teacher listened and observed, using this information to guide the next lesson. In the next lesson, the teacher presented students with an additional question: *why do some mammals gestate multiple offspring at once?* Students read informational text on the topic and focused on a set of questions attached to the text. In small groups, students answered these questions then had discussions to assess their understanding of the lesson topic. As a final assessment for this big topic of gametes and fertilization, the teacher evaluated students’ mastery through a short quiz, a peer assessment activity using stations and rubrics, and ending with a whole-class discussion.

*Students participated in engaging discussions facilitated by teacher using the SLP format.* In conversations with Ms. AZ regarding how she conducted her class before my study, it was noted that her approach took on a more traditional teaching mode, where students sat
individually and she used much of the period for lecturing. Students would take notes and participate in discussions. The implementation of the SLP-CRP unit saw changes not only in Ms. AZ’s methods, but also in the arrangement of students in the classroom. Now, students sat in groups daily, allowing them to have peer-to-peer discussions at a higher rate. The teacher’s role also shifted into facilitator mode and students assumed control of many scientific discussions. It is noteworthy to mention that while Ms. AZ did not employ strict principles of a SLP using student data to inform her future planning, she did use checkpoints and evaluations to ensure understanding of concepts before moving on to another topic. In our previous conversations, Ms. AZ discussed how she would re-teach topics if students seemed confused or unsure about anything to guarantee a level of mastery before proceeding.

For example, during a lesson on gamete development, students sitting in their groups carried on small-group discussions around the processes of spermatogenesis and oogenesis. The teacher began the lesson with a recap of fertilization to assess students’ understanding. Once this short activity was completed, she provided groups with a graphic organizer flow chart to help them structure their thoughts and ideas. In a previous lesson, the topic of gamete formation had been taught in detail. After introducing the activity, Ms. AZ allowed students to work in their groups collaborating with one another to describe the pathways involved in producing sperm and egg cells. One student correctly stated that “sperm starts out in the testes before it goes anywhere else.” Another student in that group added that the sperm then moves along the pathway to the vas deferens, then stuff is added from other organs to make semen for the sperm cells to swim in. Another student mentioned that the hormone testosterone is needed to make sperm cells. During this activity, Ms. AZ perambulated to ensure discussions were correct and to assist students when needed.
During another lesson on embryonic development, students participated in an activity where they interpreted diagrams using a graphic organizer to write down their ideas. At the start of the lesson, the teacher used a warm up activity to check for understanding of the topic completed the day before, then moved into the new topic. Ms. AZ initiated her lesson on how human embryos develop with a set of images showing different stages of growth. Students worked individually to describe what they saw from these images accessing knowledge regarding gametes and fertilization as well as prior knowledge to create a scientific explanation. Students wrote about characteristics observed such as size of the embryo at different stages, growth of physical attributes in each image, and how the embryos appearance changed with growth. Students were then instructed to think about the images and write what they thought was represented again utilizing knowledge from previous classes. The last step involved students writing at least one question or wondering regarding embryonic development. Students wrote about how food can affect the embryo, and how does alcohol and drugs affect the embryo. These questions were discussed in a whole-class forum where students shared experiences they had encountered around these questions. These nuggets of information revolved around personal experiences with friends or family members who had gone through situations with drugs and alcohol during pregnancy. Ms. AZ created a classroom environment where students felt comfortable sharing intimate details about personal occurrences bespeaking her success in improving teacher-student communication.

*Through the use of student-centered classroom activities, teacher fosters increased levels of scientific knowledge building.* One of the most effective strategies used by Ms. AZ during the implementation of this unit was purposeful, flexible grouping of students. Before this implementation, students were arranged in a traditional manner, sitting individually and rarely
sitting in groups. Students readily embraced the changes made once the teacher instructed them to sit in small groups of either three or four each. It should be noted that previously she would occasionally utilize group activities, but these were rarely conducted and students would move back to their original arrangements at the end of these activities. With the SLP-CRP unit enacted, students sat in their heterogeneous groups semi-permanently, and the teacher would reseat them only if issues arose with behavior or she simply wanted one student to work with a different group in that instance. This arrangement is a major component of working within a SLP framework to promote student learning.

Aside from lessons where formative assessments were given, students thrived in these student-centered, heterogeneous grouping arrangements. During many lessons, students would collaborate with group members for every part of the lesson unless they were quietly reading informational text, or taking personal notes. Otherwise, groups would successfully engage in scientific discourse to complete whatever activity was assigned by the teacher. I observed students completing worksheets and handouts, defining vocabulary together, answering practice questions individually then discussion and defending answers with group members, and working together on hands-on classroom activities. Ms. AZ took on a facilitator role during these instances, where she would interject if she noted students speaking about concepts incorrectly or if students could not come to conclusions about concepts in their groups after discussions. The teacher would leverage groups to assign small group discussion activities where she could perambulate to visit each group in succession to provide immediate feedback and use simple rubrics to determine understanding on scientific concepts. Students took a more active role in their knowledge building and were accountable for the material. These strategies produced a
learning environment where students carried on most of the classroom activities and had more buy-in to learn science.

Table 4.5: Emergent themes related to science instruction that arose during classroom observations.

<table>
<thead>
<tr>
<th>Themes related to science instruction</th>
<th>Examples observed</th>
</tr>
</thead>
<tbody>
<tr>
<td>The teacher’s use of SLP in the classroom allowed her pedagogy to grow</td>
<td>Teacher developed student-centered pedagogy: collaborative activities, class labs, student-lead discussions, facilitator role, etc.</td>
</tr>
<tr>
<td>Students participated in engaging discussions facilitated by teacher using the SLP format</td>
<td>Students used scientific terminology more; most students participated in discussions</td>
</tr>
<tr>
<td>Through the use of student-centered classroom activities, teacher fosters increased levels of scientific knowledge building</td>
<td>Students were given responsibility for their own learning; students came to correct conclusions and discovered concepts through student-centered activities.</td>
</tr>
</tbody>
</table>
CHAPTER FIVE

DISCUSSION

To answer the first question about how knowledgeable educators are about the use and implementation of science learning progressions and multicultural education, data was collected through semi-structured interviews with six educators from urban public high schools in the Bronx. After analysis of the data, it was observed that participants in this study were lacking in multicultural training, and they were also mostly unaware of the science learning progression teaching framework as a method available to guide them through lesson planning. These deficiencies lead to further questions surrounding how teacher education programs prepare future educators for the classroom and why teachers seem to get such little training in vital classroom skills such as multicultural knowledge and building relationships with students from diverse cultures. This study focused on the teacher, and how her pedagogical skills were enhanced through culturally relevant teaching, which then improved overall motivation of her students to learn science.

Teacher education programs (preparation) do not provide adequate multicultural education opportunities for pre-service teachers. Are teacher education programs simply not evolving with the current generation’s social, emotional, psychological, and cultural challenges and provocations or are they simply unaware that education is needed to recognize and address these tendencies?

Once an educator has completed the required graduate level program and earned their Master’s degree in their discipline, they are fully qualified to receive a Professional teaching license from New York State. The understanding is that they have acquired the skills and knowledge about strategies, theories, frameworks, and methods that would make them qualified
педагогов. The concern is that according to the responses recorded from the six professional educators interviewed, their education in graduate school was deficient in identifying and focusing on some of the urgent challenges faced by culturally-diverse students in public schools unless they were specifically enrolled in English as a Second Language programs. This presents a problem for future educators considering a career in an urban public school especially in a large system such as the New York City public school system. According to the New York City Department of Education data (2017), the ethnic makeup of public school students is approximately 27% Black and 40% Hispanic. These statistics point to a critical need for all pre-service and in-service educators in this, the largest public school system in the United States to receive proper education in identifying tactics and creating school-based plans to build bridges with students from diverse cultures. As mentioned in chapter one, approximate 80% of teachers in the United States are Caucasian as per 2011-2012 data, which is the most recent available (U.S. Department of Education, 2016).

Why is it important for teachers and other school administrators to be culturally relevant pedagogues? As educators, we encounter a vast number of students, each one of them coming from a different situation whether it be linguistic or sociocultural. It is impossible to consider teaching as merely disseminating knowledge to these young people. In fact, schools become their second home, and we as teachers provide lasting influences on their present and future endeavors. Therefore, to be an effective educator, one must consider students holistically. Consider what kind of family structure they come from, what their responsibilities are at home, how are they treated by their immediate kin, do they care for their siblings, do they have enough food to eat, are they assertive enough to ward off deviant influences outside of school, do they know how to read and write English at grade level standards? These are a few of the questions
many experienced educators consider upon meeting students for the first time. But how will new teachers begin to identify these non-academic markers that are part and parcel of young people?

After analyzing the responses from the interview participants, it is glaringly apparent that not enough focus is being placed on educating teachers to be culturally relevant pedagogues in urban classrooms. Admittedly, the scope of this study has been small, but it may be argued that the participants have all been associated with different teacher training programs where some were not even trained in science, and all have different experience and expertise levels in their field. Notably, interviewees who did receive a measure of training in CRP and/or other multicultural education strategies were part of an English as a Second Language (or Teaching English as a Second Language) program in graduate school. Here, this focus is natural since the targeted students are from culturally different backgrounds and speak a language other than English. The science coach was the only other interviewee whose intrinsic motivation led her to learn about multiculturalism on her own. She actively sought out teachers and other professionals who created multicultural strategies, and posted informational videos and other content online. Her example was of a teacher who used a popular song but he replaced the lyrics with science content, then played the song for his students, who immediately recognized and related to the music and then were blown away when they heard the science lyrics. Another groundbreaking use of music as a pedagogical method is Christopher Emdin’s Science Genius, a program that teaches and guides urban high school students the art of creating songs and poetry using science lyrics (Little, 2016). This, and other frameworks that aim to embody aspects of the everyday lives of culturally-diverse urban students are at the forefront of modern educational theories addressing sociocultural challenges between students and teachers. It is urgent for teacher preparation programs to include multicultural education in coursework.
Further, in a study performed by Rascoe and Atwater (2005), data showed that Black students were less successful in the science classroom when compared to Caucasian and Asian counterparts. Correlated with better performance is the idea of students having positive self-perceptions of their academic abilities in science. Students were shown to be very reliant on the teachers’ guidance, including simple phrases of positive reinforcement conveying a sense of support and belief in their abilities to succeed. These students needed a boost from their teachers to keep striving forward and maintaining confidence. Therefore, teachers must be introduced to strategies to help promote positivity and encouragement in culturally-diverse settings, beginning at the teacher-preparation level.

Both pre-service and in-service teacher awareness is focused on evaluation standards rather than potential teaching and instructional frameworks. The research participants showed very little familiarity with the science learning progression framework. Most were completely unaware of the existence of this guide, while a few attempted to define it through context. These responses indicate a clear deficiency in the use of available research-based frameworks in the teaching industry.

While in school, whether it’s undergraduate or graduate training, future educators are usually introduced to theoretical and conceptual frameworks in education such as constructivists frameworks, situated learning, discovery learning, and many more. The depth of training acquired varies from program to program, but while pre-service teachers are introduced to theoretical frameworks, consistent ways to successfully show them how to utilize teaching frameworks in their practice are missing. It has been previously reported that a teacher’s own beliefs regarding teaching about science will impact how they approach their own classroom (Pajares, 1992; Richardson, 1996). Many teachers, including myself were subjected to a very
traditional, teacher-focused experience in school, which also extended to several undergraduate courses. It is therefore imperative for both teacher preparation programs and schools to offer opportunities that introduce a plethora of strategies to pre- and in-service teachers, demonstrating the paradigm shift away from direct-instruction, teacher-centered classrooms to student-centered, transformative learning environments.

Other researchers have even argued for teacher preparation programs to provide experiences that change conventional beliefs about pedagogy (Yilmaz, Turkmen, Pederson & Huyuguzel Cavas, 2007). In an investigation reported by Buldur (2017), pre-service teachers in a teacher preparation program were shown to evolve their beliefs about science teaching from the beginning to the end of the program. Many teachers reportedly believed in using conventional methods in the classroom, which is how they themselves were educated. However, after being exposed to strategies that involved more student-centered, inquiry-based methodologies, these teachers revised their beliefs and became more open to transformative teaching. The significance of such a study shows the urgency of teacher preparation programs shifting or revising their offerings and providing proper coursework, workshop, and practical opportunities for pre-service teachers to build useful skills. In my analysis of educators interview responses, while very credentialed for their respective positions, they failed to utilize much of the resources that have been provided through educational and scientific research and used in their pre-service studies.

It is also fair to address how school administrators use professional development opportunities to address these issues as well. In my personal experience, most PD time seems to mainly focused on improving test scores and ensuring teachers are using the latest set of teaching standards such as the Common Core Learning Standards and the Danielson Framework for
teaching. Essentially, PD targets the betterment of a school’s graduation rate and percentages, and largely ignores the well-being of the students. Not to undermine the academic standards, but PD workshops must also provide enough space and opportunity to discuss students’ personal and social needs to some degree in addition to their academic needs. In a study completed by Love and Kruger (2005) teacher participants agreed that students’ cultural, racial, and ethnic identities played significant roles in their classrooms thus several learned how to communicate socially with their culturally-diverse students through classroom experiences and by allowing students to express their native beliefs, which also enhanced students’ motivation to learn. Most participants also believed that the ability to connect with students in and outside of the classroom helps to foster higher student achievement. This study point to aspects of CRP where the unique cultural differences of students are leveraged and used to enhance the classroom experience.

A useful way to address this deficiency would be through professional development at the institutional level. Administrators must be held accountable for providing proper training for teachers in all disciplines that allow them to advance their craft. This would require a measure of research and preparation but this effort can be fulfilled through joint assistance from both teachers and administrators. Black, Harvey, Hayden, & Thompson (1994) made the consequential point about professional development that “courses which focus on the teachers’ interests and needs, and enable them to reflect on and improve their practice, are those most likely to improve the quality of the school and develop the individual” (p. 29). Moeini (2008) also mentions that “teacher professional development is the tool by which policy makers convey broad visions, disseminate critical information, and provide guidance to teachers” (p. 2). One of the conclusions made in this article is that teachers who are provided with a high level of impactful professional development that is well thought out and implemented will be successful
in social environments that are rapidly evolving in schools that address students’ complicated needs.

Overall, pre-service and in-service science teachers require and deserve proper training from both teacher preparation programs and professional development efforts provided by administrators. Buldur (2017) states that it is urgent that teacher preparation programs provide learning experiences for pre-service teachers, especially in the sciences, to alter their mindset away from conventional modes and more towards student-centered teaching. This can be achieved through proper planning, modeling, and using examples of incorporating theories into practice. While this study can suggest that teacher preparation programs rethink their course offerings for the future, it is limited in producing actual outcomes beyond these suggestions. Professional development will however, provide such resources for in-service teachers. I argue that with proper training and opportunities, teachers can continue to refine their craft, taking both the interests of their culturally-diverse student populations and their academic needs into consideration to achieve an enriched learning environment.

Through continued, purposeful professional development, in-service science teachers can be effectively trained to incorporate and implement principles from conceptual and theoretical research-based frameworks, bridging the gap between theory and practice. The second question regarding how well teachers can be trained to use academic frameworks and multicultural frameworks can be tackled in the following way. As science teacher educators embark on the crucial role of training pre-service and in-service science teachers with their critical jobs of helping diverse students in urban science classrooms create conceptual knowledge while being culturally relevant, we must ensure training is comprehensive, and authentic. Osbourne (1996) proposed some fundamental understandings and
assertions regarding the way in which teachers become knowledgeable in their students’ cultures. Importantly, assertion one states “culturally relevant teachers need not come from the same ethnic minority group as the students they teach”. While this may seem like an obvious statement, it is essential to recall that approximately 80% of teachers in the United States are Caucasian, while according to the National Center for Education Statistics (2017), the number of Caucasian students enrolled in public schools decreased to 50%, while the number of Hispanic students increased to 25% and the number of Black students decreased by a small percentage from 17% to 16%. These compelling statistics continue to point to an increasingly urgent demand for culturally relevant pedagogues in public school classrooms across the United States.

Ethnically, my teacher participant Ms. AZ is Jewish Caucasian and went to traditional Jewish schools for most of her education. However, as an individual raised in the New York/New Jersey region and her desire pursue teaching within the New York City public school system, she immediately recognized the importance of being sensitive and knowledgeable to diverse cultures.

Osbourne’s (1996) second assertion states, “socio-historico-political realities beyond the school constrain much of what happens in classrooms and must be understood well by the culturally relevant teacher”. Pre-service teachers enrolled in teacher preparation programs that offer courses on the social, historical, and political aspects of education as well as education in diverse urban classrooms can serve as a proper training platform for future teachers. In-service teachers however, often rely on the judgment of administrators to provide professional development workshops. In most instances, workshops are built around standards and benchmarks and assessments instead of focusing on the social well-being of students. It is thus imperative that teachers advocate for culturally relevant workshops or audit a university course to gain the knowledge and insight into being a culturally relevant pedagogue. Ms. AZ was
fortunate to be enrolled in a graduate education program where courses such as these were part of required sequence. She completed an English as a Second Language (ESL) program, and naturally many of her classes were focused on useful strategies for students coming from diverse cultures. She was therefore already prepared upon meeting her students for the first time. Admittedly, many teacher education programs fail in this vital necessity, especially programs that are science-focused. Ms. AZ completed an undergraduate degree in Chemistry, therefore it was not required for her to complete courses in education or sociocultural sensitivity. In our sessions, I found it remarkable that she knew of many strategies and she already used several of them in her classes. She was sensitive to the needs of her students, both academically and personally. Some students came from difficult home situations, and would feel comfortable approaching Ms. AZ to discuss schoolwork but to also have personal conversations and ask her for advice. Many new teachers rely on graduate programs to provide the necessary training that will properly equip them for entry into the classroom. It is therefore critical that teacher education programs introduce courses that provide the urgent training in socio and cultural knowledge of students so that new teachers possess a complete set of skills for this highly demanding career.

Thirdly, “it is desirable to teach content that is culturally relevant to students’ previous experience, that fosters their natal cultural identity, and that empowers them with knowledge and practices to operate successfully in mainstream society”. One method of achieving this goal is to encourage the use of students’ experiences outside of the classroom when relevant to topics being taught. For example, referring to their urban neighborhood when discussing topics in ecology like trees and plants, food webs, and food chains. It is also reasonable to allow students to refer to their indigenous species in activities and discussions and to speak in their native
language when appropriate as well.

Assertion four states, “it is desirable to involve the parents and families of children from marginalizes and normalized groups.” I believe this assertion needs to be developed and encouraged to a greater level in many urban high schools. While there are official parent-teacher conferences throughout the school year, this minimal level of communication is not nearly enough to foster lasting relationships between schools and parents/guardians. Schools must be allowed the space to organize more events and opportunities for parents/guardians to get involved in their children’s’ learning processes. This understanding is directly related to assertion five, which states, “It is desirable to include students’ first languages in the school program and in classroom interactions.” Personally, I am monolingual, however, as a teacher who spent the first seven years of my teaching career at an urban public high school in the Bronx with approximately 60% Hispanics whose native language was Spanish, I learned numerous words and phrases and highly encouraged the use of students’ native language in the classroom once it was appropriate to the lessons and discussions. This strategy has been very effective with respect to building communication bridges with students from diverse cultures and with creating an authentic space in the classroom where students feel comfortable and encouraged to be true to themselves. Currently, I teach at another multi-ethnic high school in Brooklyn, but students here come mainly from Chinese and other Asian countries. I have adapted the same strategies used in the Bronx to also encourage these students to use their native language and culture in the classroom since it sometimes brings comfort and allows them to feel at ease. Even though the materials are provided in English, students can make their notes in their native language.

Ms. AZ also allowed students in her science classrooms to express themselves using their native languages. Students in the classroom observed understood that as they progress with
learning the English language, teachers will not prohibit them from expressing their native culture in school. However here students were more explicitly addressed and guided, and the atmosphere created was natural and fluid, where students knew the subtle boundaries between academics and too much personal expression. Ms. AZ could readily bring the class back into focus if they strayed too much. In her traditionally-taught classrooms, we spoke about her teaching methods where she intimated that her instruction was not as explicit, and students were more disorganized, easily distracted, and sometimes discourteous to one another. Even when Ms. AZ allowed the use of other languages and expressions, she would have a burdensome time getting them focused as they were more obstreperous.

Assertion six states, “culturally relevant teachers are personally warm toward and respectful of, as well as academically demanding of, all students.” This sentiment holds true for a highly effective teacher with proper training as well as insight into how children learn. It is highly imperative for teachers to reconcile their own beliefs about the teaching profession, ensuring that they are in it for the right reasons. This is the only way to become invested in their students’ progress academically and socially. One major plan of action Ms. AZ employed at the beginning of the school year was to spend time talking to her students and becoming as familiar as possible with them and their complicated lives. In his bestselling book, *For White Folks Who Teach in the Hood and the Rest of Y’all Too: Reality Pedagogy and Urban Education*, Dr. Christopher Emdin describes the use of Reality Pedagogy in urban classrooms as a proven method of making a connection with students by allowing them to use cultural and emotional expressions as a way of learning. Ms. AZ’s approach was not as formalized and structured as this, but it represents an approach to allowing students from diverse cultures to negotiate personal experiences in a positive way by forging relationships with other students and the
teacher early in the school year.

Assertions seven and eight are directly related in that seven states, “teachers who teach in culturally relevant ways spell out the cultural assumptions on which the classroom (and schooling) operate,” and eight states, “there are five components of culturally relevant classroom management: using group work, controlling indirectly rather than confrontationally, avoiding “spotlighting,” using an unhurried pace, using the home participation structures of the children.” Both assertions point to strategies that, when used properly, help determine how students ultimately behave in the classroom. By being very explicit about expectations regarding culture, social behavior, classroom routines and norms, students are given more accountability, therefore rendering their presence in the classroom vital and their willingness to learn increases.

At the beginning of this study, I had several discussions with Ms. AZ leading to more formalized professional development meetings to help her prepare lessons and activities that aligned to the research questions and ideas. Being a second-year teacher was advantageous in that she was well experienced with the material and she was already armed with strategies for increasing motivation and interest in students. Additionally, being a science teacher in a struggling school meant that the Department of Education provided the school with some additional assistance in terms of coaching and curriculum development. At the point in time of my study, science teachers were required to implement the New Visions Science Curriculum (see appendix E), which has been formatted to fit a science learning progressions framework. Her department had already adapted portions of New Visions into lessons and further adapted these lessons to meet the needs of students in the classroom during departmental professional development sessions. Ms. AZ was already very comfortable with her students, having been with them since September, thus many of the routines and rituals of the classroom were well
established. Throughout my informal training sessions with her and my classroom visits, she demonstrated her desires and abilities to build upon her pedagogical experiences as a willing participant in this study. Her bold and honest responses to the questionnaire at the end of our sessions further denoted the depth of her teaching skills, her scientific knowledge, and her proclivity for helping her students learn in an agreeable classroom environment. She was successful in her attempt to use an exemplar of the science learning progression unit while incorporating culturally relevant pedagogical strategies in the experimental classroom and sometimes in the regular classroom as well, although these incidents were not premeditated.

The question of whether it is possible to train science teachers to use elements of culturally relevant pedagogy throughout their science curricula has been conclusively and favorably answered through this effort. Ms. AZ was successful in using the opportunities with me to learn about science learning progressions, cultural relevance, and how to achieve a balance between both frameworks in her culturally-diverse science classroom. She would be able to turnkey this work to other teachers in the science department and other disciplines at her school. She would demonstrate her successes with building relationships with her students, enhancing their motivation, and allowing them to hold more accountability, resulting in a superior learning environment that fosters scientific conceptual knowledge building. Additionally, she would now be able to introduce the notion of using formal, research-based frameworks that merge divergent ideas into a fluid and dynamic set of key ideas that can be adapted into all science disciplines and expanded into other disciplines.

The reasoning and rationale driving this study came from a decidedly lack of published empirical data demonstrating the practice of integrating cultural knowledge in science classrooms in urban public high schools. There are numerous conceptual and theoretical
frameworks in education literature that educators can adopt for use in science as well as any other discipline. There is also a plethora of multicultural research encompassing strategies and frameworks that can be successfully implemented in culturally diverse settings. Authors like Gloria Ladson-Billings, Felicia Moore Mensah, and Christopher Emdin have dedicated their careers to studying under-represented urban youth and discovering methods to help these students become willing participants in the challenging process behind constructing scientific knowledge. Still missing in the literature is an example of a framework or exemplar that successfully combines an instructional framework with the elements of culturally relevant pedagogy in K-12 classrooms. As mentioned earlier, one of the major goals of this work was to create a practical exemplar using two divergent sets of principles in a novel approach. After spending the first seven years of my teaching career at a culturally-diverse, under-represented school in the Bronx, it was a forgone conclusion that analyzing ways to merge science teaching with culturally responsive teaching as a way to help students construct scientific knowledge in an urban school setting via having teachers who are trained to help students achieve these goals would be the most effective path to take. The focus had to be on the teacher, identified as the guiding and driving force behind how well students can construct new knowledge. For discussion purposes, outcomes will be explained through the lens of constructivist theory, which has been described as a ‘major theoretical influence in science education’ (Matthews, 2002).

Students in the SLP-CRP classroom were more academically engaged in learning and were able to construct scientific knowledge. Aside from its impact on the way educators view the learning process, constructivist theory has highly impacted national policy making from such organizations as the National Science Teachers Association (NSTA), the National Council for teachers of Mathematics, the National Research Council, and the US National Science
Teachers Association Standards for Teacher Preparation. The far reaches of this theoretical model are largely due to its major influences in science, philosophy, and psychology, along with its claims in pedagogy and epistemology (Matthews, 2002). While the creation of this teaching exemplar was achieved by consolidating components of a science framework with a multicultural education framework; the ultimate goal is to determine the enhancement of students’ construction of scientific knowledge via a classroom environment that has been rendered sensitive to their needs and preferences. To achieve this, the teacher must be trained to recognize, identify, and utilize the rich, diverse cultural backgrounds that students come from.

Harding (1993) discussed the challenges faced when people attempt to construct scientific knowledge. While her focus is mainly on masculine biases in scientific endeavors, she alludes to challenges faced by many students in diverse science classroom settings as well. Harding states: “one’s social situation enables and sets limits on what one can know.” She continues by noting, “what makes these situations more limiting is their inability to generate the most critical questions.” Harding’s analysis hits at the core of the problem explored throughout this work. It is the environment that determines the type of questions that can be asked as well as the type of thinking that can take place. Although Harding works within the framework of societies, if we view the classroom as a mini-society it becomes easier to apply Harding’s research. Her standpoint theory describes the tyranny of the majority and how the majority limits the amount of knowledge the minority can gain. Teachers who choose to make students’ acquisition of knowledge the focus of every lesson empower them to take control of their environment and their overall progress. These students are given the power to take control of both the classroom environment, and by extension the larger society that they are a part of.
There is ample evidence arguing that when teaching strategies are created with students’ cultural backgrounds and native experiences in mind learning is positively impacted (Lee and Luykx, 2006). In this study, students who received instruction through the use of a science learning progression unit with elements of culturally relevant pedagogy were afforded opportunities to enrich their learning through authentic discussions and activities integrating their own cultural experiences and expertise. The classroom was transformed into a mini-society where students took the reins, lead the discussions, facilitated their own learning, and self-assessed their knowledge through questions and conversations. The teacher allowed them to collaborate and by extension, they discovered much information through their own efforts with the teacher acting as facilitator.

Driver et al. (1994) discusses social constructivism from the angle of the science classroom as well. In this article, the authors draw upon Vykotsky’s work as told by Bruner (1985), where Vykotsky claims that individuals could not possibly construct the volume of worldly knowledge that is available without the help and interactions of other people. From this standpoint, scientific knowledge is constructed when individuals participate in social interactions, including discourse and activities to share and create information about common problems and tasks. In these settings, a new culture is introduced to an individual by a member of that culture and the tools needed to build knowledge in this new culture are acquired through increased interactions by more experienced members teaching the less experienced members of the culture. With respect to science and science education, this information is vital to learning. Unlike cognitive constructivism, which can be considered personal empirical inquiry, social constructivism allows science learners to construct the specific knowledge that is true to science.
Through social interactions with experienced members of scientific culture, individuals can build the physical and conceptual knowledge that is conventional science (Driver et al. 1994).

Two of the main emergent themes noted during classroom observations was that students in the observed classroom engaged in academic activities and discussions at a greater rate and the teacher garnered more respect from students in the SLP-CRP classroom. In fact, the teacher easily facilitated discussions with students, eliciting quality responses and encouraging student-centered discussions driven by the concepts being taught. Admittedly, the teacher used familiar language at times with students, which also brought a level of comfort and ease to the learning process and smoothened the discussions taking place. Students spoke to each other with more respect and appreciated the classroom space as a learning environment. Altogether, students in the observed classroom were able to utilize their social interactions in an academic setting to construct new scientific language successfully.

Creating routines, which became rituals increased motivation and overall positive thinking. The students observed in this study are mainly from cultural, racial, and ethnic backgrounds that are considered as varying from the cultural norms of Americans. Many are young people with different lifestyles and different belief systems. These young people were raised in home environments where education may not have been the cornerstone of success and where parents and/or guardians did not stress the significance of being in school and some of them may not have attended formalized schools at all. Motivation and emphasis on learning for many students come from the people they interact with at school, namely teachers, counselors, administrators, and even office personnel. To this end, all adults who encounter students from diverse cultures must be familiar with strategies that embrace, not marginalize differences in
cultures. Previously, the role of the teacher in creating positive routines and by extension, rituals in the classroom was discussed.

Becker (1963) alluded to student deviant behavior when they are labeled by teachers and administrators in this light and stressed that such a student might feel coerced into continuing negative behavior, which gives them a deleterious label that impacts future behavior. Becker also mentioned the role of developing classroom rituals as a method of creating positive behavior in previously negative-type students. It is therefore imperative that teachers, especially those in urban public high schools project a categorical environment of tolerance and learning. Related to this, it was noted in observations that students developed a clear set of routines early in the school year, even before this study commenced. These simple routines, such as picking up handouts, sitting in groups, using laptops or ipads, handing in homework, and giving out textbooks, as well as small classroom roles during activities; after being enacted daily became the positive rituals of the classroom, empowering students into making the space a personal learning endeavor. Thus, not only did students build scientific knowledge socially and cognitively, some students developed rituals in the daily running of the classroom thereby directing possible negative behavior into more positive but simple roles. The teacher allowed them to become invested in both their learning and the successful running of their classroom, giving all students value and purpose. This in turn helped create and boost intrinsic motivation to be present every day.

**Students were encouraged to incorporate indigenous knowledge in the classroom.**

Laurel Schmidt (2008) discusses how students learn through Bloom’s taxonomy, which includes knowledge, application, comprehension, synthesis, analysis and evaluation as a useful hierarchical strategy to help educators create meaningful activities and questions in their daily
lessons. She also mentions Dewey’s belief that knowledge should be built around students’ lives and fully integrated into their everyday experiences. In this study, students in class A were encouraged to make use of the knowledge they build from non-academic situations by incorporating the information in relevant ways in the classroom. By combining the concepts of Bloom’s taxonomy, where a skilled teacher can begin a concept with facts and vocabulary but continuously increase the complexity of the lessons, with providing spaces for students to express their understanding through the use of their native cultures as per Dewey’s beliefs, learning science becomes an interesting and authentic experience for students. Related to this, students in the observed class were given opportunities to build their knowledge on topics in a progressive manner. Another noted theme: utilizing a variety of learning modes and materials to significantly differentiate challenging concepts allowed students with varying learning levels to construct knowledge. Also, the use of high-level questioning, positive reinforcement, and facilitation allowed students to discover concepts. Both themes allude to a teacher who has taken the time to not only learn pedagogical techniques, but who had gotten to know her students on a more personal level, taking their experiences and personal lives into consideration, and negotiated the classroom environment to their benefit. These strategies allude to using principles from both the SLP and CRP frameworks.

Schmidt (2008) briefly mentions Paulo Friere, who has written numerous pieces of literature on how young learners must be empowered through the use of discourse and dialogue, critical thinking and active learning. Rugat and Osman (2013) discussed some of Friere’s philosophical underpinnings with regard to education of young people, especially those who come from diverse, and less fortunate backgrounds. Friere strongly believed that education’s function is not meant to inflict the culture of teachers on students, but to allow them to
conceptualize new knowledge by strengthening their skills, experiences, and language, and having the opportunities to do so. Friere held the poorest and most oppressed students to the highest esteem, which he surmised would create a safe and trustworthy relationship between students and teachers. In *pedagogy of the oppressed*, Friere philosophizes that education should be framed in a dialogue setting where both teacher and student benefits from a collaborative activity instead of a one-way lecture from teacher to student(s). In doing this, the relationship becomes more balanced and less authoritarian on the part of the teacher (Friere, 1996). Overall, Friere’s philosophy can be applied to this setting since the teacher successfully found ways to integrate culturally relevant pedagogy principles into her science lessons, while doing her best to empower her students and allow them space to learn, discover, and construct knowledge. Students used these advantageous opportunities to enhance the relationship with the teacher and expand their scientific knowledge building by accessing prior knowledge and using interactions to learn more.

The SLP-CRP exemplar, while introducing multiculturalism also conserved scientific rigor. A major concern surrounding a shift in curriculum and pedagogy that was mentioned by education stakeholders is the level of rigor in the classroom. How does the introduction of CRP elements affect rigor in the science curriculum?

It can be noted that rigor in this SLP-CRP reproduction unit was fully maintained at high levels. Firstly, the curriculum used has been written based on the New York State Core Curriculum (2016) and it is fully aligned to the Common Core Learning Standards, while also being written with the principles of a SLP. Secondly, the curriculum provides a variety of student-centered activities which promote learning and deep thinking. Lastly, adding elements of CRP to this unit helped motivate students to become more engaged in scientific learning as
they felt more comfortable with the relationship they established with the teacher, and they developed a strong interest in actively participating in the classroom process.

**Implications**

The results of this study have highlighted several deficiencies as well as several accomplishments regarding pedagogical practice. One deficiency stems from lack of specific multicultural course offerings in teacher preparation programs, rendering teachers insufficiently trained with culturally relevant strategies. In this study, the science teachers interviewed came from traditional teacher preparation programs and non-traditional programs such as the New York City Teaching Fellows and Teach for America. These educators spoke of the lack of course offerings in their programs that targeted multiculturalism. Also noted is the gap between formal educational theories used in education courses and their actual application in practice. I can only suggest that in the future, teacher preparation programs make concerted efforts to provide multicultural opportunities for future teachers as well as real-world, practical opportunities showing them how to incorporate theoretical methods into actual practice.

Many administrators choose to focus solely on ineffectual aspects such as school numbers and evaluation frameworks while neglecting academic and social necessities for students to be successful. This can be remedied with targeted professional development workshops that focus on helping students both academically and socially.

One major accomplishment was the successful training of the teacher participant in the use of a CRP-SLP framework and her positive reception towards learning about and engaging with theoretical frameworks to guide her planning and practice. This can be further applied to other members of faculty through professional development workshops that introduce and model how these frameworks can be exercised in practical ways. Through continued practice, school
leaders and in-service teachers can reconcile research-based instructional approaches with actual practice, narrowing the gap that exists between theory and practice.

**Limitations**

One major limitation encountered in this study was the presence of teacher bias in choosing the classroom observed. The teacher was aware of the study goals and she implicitly selected a set of students who would be receptive and corporative with me being present and with different teaching methods being used. While not perfectly behaved, these students had established a semblance of decent behavior in the classroom. Secondly, due to time constraints, it was only possible to create a SLP-CRP exemplar covering on unit of instruction instead of focusing on more topics.

**Next steps**

Qualitative data collected described the improvements made to the relationship between students and the teacher in the SLP-CRP. Analysis of discourse between the students and teacher involved demonstrated increased scientific knowledge building, increased use of correct scientific terminology in discussions, increased organization within the classroom, and overall increased interest in science. It was noted that students were able to use social discourse and prior scientific knowledge to enhance and build new knowledge in a constructivist manner through a combination of collaboration with peers and facilitation by the teacher. Students expressed higher levels of interest in the science content, and practiced a high level of respect towards the teacher during classroom.

For the next steps, this methodology of integrating elements of CRP into a SLP or any other science curriculum can be applied easily to current academic standards and integrated into current curricula being used in schools. The design of the SLP model allowed the teacher
participant to incorporate many student-centered activities and discussions thereby shifting her pedagogical mode from strictly instruction, to more transformative. She was also successful in her use of CRP. The elements of CRP are uncomplicated and simply requires the teacher to be more receptive to students’ multicultural backgrounds. School leaders can use available resources to locate experts in the field to implement purposeful professional development workshops. I am confident that when teachers are exposed to strategies that can improve students’ overall motivation and behavior, they will not hesitate to introduce these ideas into their pedagogical practice.
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APPENDICES
APPENDIX A: PILOT STUDY
Pilot Study

The primary focus of this study was to describe how science teachers in an urban public high school perceive multicultural education and science learning progressions. The study aimed to answer questions regarding teachers familiarity with learning progressions and its successful implementation in high schools; teachers exposure to multicultural education as well as how they feel about becoming intimate with students’ cultures, and will this visible knowledge affect student learning. Data were collected from science teachers in an urban public high school in New York City.

Pilot Study Research Questions

Science/biology teachers enter into urban public high school classrooms with content knowledge and pedagogical skills learned in teacher-preparation programs or through professional development workshops.

1. How well do these programs address issues of multiculturalism that science/biology teachers inevitably encounter in urban schools?

2. How well do these programs address issues of students’ differing learning abilities? Are teachers sufficiently prepared to handle the voluminous amounts of planning and preparation that are required of them?

Field Setting

This research study was carried out at a New York City public high school in the Central Bronx, New York. The study took place during school hours of 8:30am to 3:20pm, while classes were being conducted. The school is an inner city, urban high school located in a poor socio-economic neighborhood where almost one hundred percent of students receive free lunches (Title 1 school), and approximately thirty percent of students have Individual Education Plans.
(IEPs). Demographically, approximately 63% of students enrolled are Hispanic, while 34% are African American/Black (New York City Department of Education, 2013).

Participants

My participants were New York City public high school science teachers who currently teach Living Environment, Chemistry, and a Special Education science teacher. The Living Environment teacher is a sixteen-year veteran of the New York City Department of Education, the Chemistry teacher is in her second year of the profession, and the Special Education teacher has been on the job for approximately fourteen years.

Approach

This study was conducted using an intrinsic qualitative case study design. Merriam, 2009 defines a case study as “an in-depth description and analysis of a bounded system”, while Creswell, 2013 describes it as “a methodology: a type of design in qualitative research that may be an object of study, as well as a product of inquiry”. I chose to look at how science teachers in a public high school perceive students learning abilities and multiculturalism in their classrooms. This was the subject and bounded system of my case study. Through various methods of data collection, a strong rationale for using this design method was to verbalize the concerns and implications of teachers faced with situations that they were never prepared to address.

Data Collection

Semi-structured Interviews. Consistent with case study design, I identified school faculty members as multiple sources of information for interviews through on-site observations and informal discussions to determine who would be most appropriate for an in-depth interview. The interviews were conducted in a semi-structured manner and lasted between five and ten minutes. Open-ended interview questions were asked about teacher-preparation programs, science
learning progressions, and multiculturalism. The interviews were transcribed verbatim for analysis.

*Questionnaire.* Data was collected using a Likert scale questionnaire, which I designed. Each individual was given a copy of the questionnaire and asked to take approximately ten minutes to think deeply about the questions before making their choices. The questionnaires were collected for analysis and correlated with interview responses.

**Data Analysis**

The data was initially organized into files. Interviews were recorded using a voice-recorder and subsequently transcribed manually. Text was read through several times, and the bracketing method was used to identify initial emerging codes throughout the data. This information was then recorded and analyzed for consistent themes and emerging patterns from what interviewees stated. From initial codes, categorical aggregation was used to establish common themes from interviews that were supported by questionnaire responses. The Likert questionnaires were read through and analyzed, thus identifying consistent themes with data collected from the four sets of interviews.

These themes were then used to interpret the data and to develop naturalistic generalizations based on emerging ideas.

**Raw Data**

*CL Interview:*

CB: So this is an interview with a chemistry teacher who teaches mostly 11th and 12th graders in high school. Hi!

CL: Hi!
CB: I’m going to ask you just a few questions about science learning progressions and multicultural education and I’m just looking for brief answers from you, ok? Ok, so number one: Are you familiar with the concept of a learning progression? If yes, describe your understanding of what a learning progression means and if not, describe what you think a learning progression might be.

CL: Ok, so I’m not familiar with a learning progression. What I would assume it means is scaffolding in a sense of how you teach. So going from a simple concept that the students may be somewhat familiar with and then getting more detailed and in-depth with that concept. Ok, that’s brief for you.

CB: Yes, ok thanks. Number 2: There are learning progressions for all disciplines. Science learning progressions are a bit different from others because these sequences are guided by empirical evidence collected from research. Do you think this type of framework can be effective if implemented for all learning levels? Why or why not?

CL: Effective in the sense of using empirical research?

CB: Yes. Using empirical research and using the learning progression as you think it is.

CL: Ok. I think so because I think it would be application of my understanding of, my assumption of what a learning progression is. And, actual analysis of how students have learned and, in terms of different concepts. I would think that would be appropriate for all disciplines.

CB: And learning levels? Like, for science? Science learning levels. Meaning, ELLs, Special Ed., you know, and general ed.

CL: Yes, I think it would be….yes, for all learning levels I think that would be appropriate as well, yes.
CB: Alright, so, multicultural education. One: in your own teacher-preparation program, do you recall learning about or being exposed to multiculturalism and/or frameworks that integrate student culture into teaching such as culturally relevant pedagogy?

CL: My training, was… it was implied that we knew we would be working with students of different cultures but we were never really taught how to teach them. In a sense of what they’ll understand in terms of their culture and their ideas of things. It was implied that we would be working with them but not how to teach them. So, anything that I have learned in terms of teaching, like, multicultural students has been on the job, learning as I go along. There has not been….we were kind of just thrown in. There was no training.

CB: There was no training?

CL: No official training.

CB. Alright, so number two: Do you believe that it is necessary for science educators to become familiar with their students’ cultural backgrounds? And to what extent do you think this should be done?

CL: I do think it’s necessary…..I think teachers should have a good base understanding of the different cultures and how they view, specifically science, because a lot of students have trouble engaging with science because they don’t relate to it. So making things relevant and meaningful to them will help them engage with it. So in order to do that, teachers need to have some sort of background information about what exactly do these cultures entail. So I think that’s very important and I think it should be somewhat in-depth to fully understand or fully grasp the concepts these cultures, like, have incorporated into them.
CB: Ok, thank you. Number three: Do you believe that incorporating opportunities for use of cultural and linguistic elements of students’ backgrounds will change attitudes and overall learning experiences of students? And can you explain a little bit?

CL: So, how to change the teachers’ attitudes?

CB: No, the students. Yes.

CL: The students? Yes, I think that the students, they’re aware the teachers have some sort of background knowledge then they would be more likely to relate to the teacher because a lot of times you have a students from some sort of minority and the teacher is not. So the student automatically goes to “you have no idea what I’m going through,” or something like that. That’s just like surface value when you meet someone. So I think that would improve the attitudes of students if they were….if teachers were…..

CB: And do you think that that would, like, increase their learning experience and increase they’re, maybe they’re interest in……even if it’s something as complex as Chemistry?

CL: Yes. I think it would because I think it would allow the student-teacher relationship to be stronger. And, so that just based of having a good relationship with the student is going to make them potentially more likely to be engaged with the subject matter and even just coming to class or caring about the subject. Because they want to, like, have the teacher be proud of them and their accomplishments and so I think, definitely is a big thing.

CB: Ok, thank you, that’s it!

CL: You’re welcome!
DM Interview:

CB: Ok, so I’m going to just ask you a few questions, and we can keep it as brief as possible. So the first set of questions is about science learning progressions. First question is: are you familiar with the concept of a learning progression? If yes, describe your understanding of what a learning progression means and if not, describe what you think a learning progression might be.

DM: Well, I’m thinking more like a pre-assessment and an assessment later on to see where they are.

CB: Ok, that’s it? Ok. So number two: there are learning progressions for all disciplines. Science learning progressions are a bit different from others because these sequences are guided by empirical evidence collected from research. Do you think this type of framework can be effective if implemented for all learning levels and why or why not?

DM: I believe that every class should have a component like we have lab. So that’s a hands-on approach. I think that’s a great idea, especially for special education.

CB: Ok. So the next set of questions is about multicultural education. Number one: In your own teacher-preparation program, do you recall learning about or being exposed to multiculturalism and/or frameworks that integrate student culture into teaching, such as culturally relevant pedagogy?

DM: I haven’t really been exposed too much to it, but I actually bring it into the classroom when I can because I have a small group that I teach.

CB: Yes.

DM: So I like to be very personal with the students. I don’t know if that’s everybody’s approach but I like it, it works for me.

CB: but when you went to school before….
DM: You mean as a kid?

CB: No, I guess as an adult in college, did you have anything about….any classes you recall?

DM: I can’t recall, honestly, but there was one class I had to take that was an overview of all the different types of learning disabilities.

CB: Ok.

DM: And the requirements of the class was to go and sit in different settings. I learned at that point different…..how can I say this….curriculums and different classroom activities for different types of students. We’re talking the gamut; from retarded children all the way to just learning disabled children in your inclusion classes. So I actually did a lot of that. So I learned different things but I don’t think that was part of the curriculum.

CB: You mean multiculturalism?

DM: No, I don’t think so. But I remember teachers bring that in.

CB: Ok, do you believe that it is necessary for science educators to become familiar with their students’ cultural backgrounds and to what extent do you think this should be done?

DM: Look I’m going to reiterate the same thing. It works for me all the time because I like to become personal with the kids. So I’m not sure exactly….what that exactly brings into their grade but it sure makes them feel like they’re part of the class. So that helps me. So I agree with all of that.

CB: Ok, do you think that maybe as teachers we should be taught about multiculture and…..

DM: Yes, definitely.

CB: Ok, and last question: do you believe that incorporating opportunities for use of cultural and linguistic elements of students backgrounds will change attitudes and overall learning experiences of students.
DM: Absolutely, positively.

CB: Can you explain maybe why you think it would change their attitudes?

DM: Because I’ve seen it work. I’ve done it for years.

CB: So through experience?

DM: Through experience, yes, absolutely.

CB: Ok, that’s it, thank you!

DM: That’s it? You’re welcome.

_JM Interview:_

CB: Ok so I’m going to ask you just a few questions about two frameworks and you can just be honest and brief about them. So the first ones are science learning progressions. Number one question: are you familiar with the concept of a learning progression? If yes, describe your understanding of what a learning progression means and if not, describe what you think learning progression might be.

JM: Ok, I don’t know per se what a learning progression is….but, the way I always approach teaching is that there has to be some fundamental knowledge and then we build upon it. So, we progress with student understanding by developing basic concepts and then taking it maybe a step further and then going deeper. So there’s that progression to learning.

CB: Ok, thank you. Number two: there are learning progressions for all disciplines. Science learning progressions are a bit different from others because these sequences are guided by empirical evidence collected from research. Do you think this type of framework can be effective if implemented for all learning levels? Why of why not?

JM: It’s a hard question to answer because I don’t know what the empirical data could be…..
CB: Just observing, you know…

JM: But, I was thinking any discipline, whether it’s math; a student needs to know how to add before he can learn how to multiply and to learn how to subtract before they really can conceptualize division. So, I would think that just like a student or a child would learn to read before they learn to comprehend what they’re reading, that in every discipline….and even with social studies, I think that once we have certain facts then we can understand the whys. Why of war, why of conflict, why of economy; once they understand what the facts are. So I think yes, progression is in every discipline but I don’t know if the model that’s being used would apply.

CB: Well ok, so do you think it would work for example, the kids that we see everyday? The strugglers, the ones with IEPs, the ELLs?

JM: I absolutely think that you have to teach with progression. You know, I know that a lot of the ‘what’ type of questions are frowned upon, but they take me to my ‘why’ and ‘how’ questions.

CB: Ok, alright, thank you. So the next set are three questions about multicultural education. Number one: in your own teacher-preparation programs do you recall learning about or being exposed to multiculturalism and/or frameworks that integrate student culture into teaching such as culturally relevant pedagogy?

JM: I’m going to answer that really honestly. I remember seeing a course name that said ‘multiculturalism’ but I don’t remember anything about it and even to this day I wouldn’t know what that really means. Because I don’t know that learning is cultural, I really feel that a lot of…..in our school, learning issues are socioeconomic and exposure. Because I don’t think that there’s any particular ethnic group that doesn’t value education, and one that does.
CB: Number two: do you believe that it is necessary for science educators to become familiar with their students’ cultural backgrounds and to what extent do you think this should be done?

JM: I think it’s important for all human beings to understand other people’s cultures and respect it. But as far as education, again, it may not be a popular belief, but I believe that children are children and they’re here to be educated and there’s a way to approach the mind and it’s not really cultural.

CB: Ok, and number three: do you believe that incorporating opportunities for use of cultural and linguistic elements of students’ backgrounds will change attitudes and overall learning experiences of students and explain if you can.

JM: I’m not sure if I really understand the question.

CB: Ok, so we have a lot of kids from DR and Puerto Rico and if all teachers were to use, sort, of, aspects of their culture in lessons, do you think that that might change the overall attitudes of the students themselves and maybe increase their learning experiences?

JM: I personally don’t.

CB: No? Ok.

JM: And the reason that I personally don’t is that I see standardized tests change over the years from names like ‘Sally and John went to store and bought two apples’ to ‘Juan and Maria or Deshawn and another name, and even Mohammed and someone else,’ but when the fundamental math problem comes about, I don’t think it really matters if you can relate to the name. I think also that in education, for example American History, we’re learning it from a certain perspective and I think that we in a sense do a disservice to our students to keep revisiting a culture.

CB: Ok, that’s it. Thank you.
Questionnaire analysis

The questionnaire consisted of eight questions with the first three items related to learning progressions and the last five items related to multicultural education. Respondents were asked to take time to think deeply about the questions being asked before checking a box.

Ms. CL gave neutral responses to the majority of questions, except the last two, which were related to combining science pedagogy with multicultural elements and the cultural sensitivity of her students.

Ms. DMs responses was incongruous with her interview responses. While she clearly stated that she was not familiar with learning progressions, she strongly agreed with the items on the questionnaire that asked about her knowledge of learning progressions, and her use of learning progressions in the classroom. She also strongly agreed that multicultural elements should be used in the science classroom since many students are from different cultural backgrounds.

Although Ms. JM denied knowing what a learning progression was, she strongly agreed that she knew what a science learning progression was together with her use of this framework in her classroom. She reiterated her beliefs regarding a culture-free classroom but did strongly agree that her students were culturally sensitive.
Interpretation

Based on the responses received by these three science teachers, it is apparent that in-service and most likely pre-service science educators are not fully prepared to use novel theoretical frameworks as tools for designing pedagogical practices, nor are they able to display cultural competence in the classroom.

From the data, the newest teacher, Ms. CL displayed the most comprehensive knowledge and perspectives about the two theories, without having absolute understanding of their intricacies. She clearly linked learning progressions to scaffolding material, a techniques used by many educators as a means of progressing from simple, recall concepts to the advanced complexities that require critical thinking skills. Ms. CL was also very aware that her students are culturally different and may require a different skill-set from teachers in order to internalize the same knowledge that indigenous students can immediately grasp.

At the beginning of my interview with Ms. DM, I was struck by her lack of interest in the questions being asked, and the extreme brevity of her responses. Although she did try to give appropriate responses, my sense was that she refused to think about the questions being asked before answering, and her responses were not in-depth. She spoke about special education students when referring to every question and although these are also minority students, I’m not absolutely certain she understood that I was asking about multicultural education and not about students with special needs, which are two different issues. She mentioned the use of pre- and post-tests as a part of a learning progression, as well as the use of hands-on lab activities. These ideas, although not very targeted are indeed incorporated into learning progression sequences as measures of progress and as formative assessments. I was a bit confused with her questionnaire responses since these did not correlate with most of the interview answers she gave, although one
explanation could be that she believed her answers to be one hundred percent accurate even though she was unfamiliar with the terminology.

Ms. JM’s interview responses were surprising but not entirely unexpected. While unfamiliar with learning progressions, she stopped and really pondered the question before presenting me with her interpretation of the theory. It was impressive that she included other disciplines like math and reading, demonstrating her use of experience and prior knowledge to answer the questions asked. The surprise came when she expressed that she did not believe that culture played a significant role in student learning. She was adamant about not placing cultural expectations on her students and she admitted to not using culturally sensitive pedagogy in her classroom. Instead, she believed the issues are more significantly related to low socioeconomic statuses of families, and students’ cultural backgrounds are not a causal element of academic deficiencies. Her questionnaire responses were congruent with the interview analysis.
APPENDIX B: SEMI-STRUCTURED INTERVIEW QUESTIONS FOR TEACHERS
Pre-implementation Interview

1. Are you familiar with the concept of a learning progression? If yes, describe your understanding of what a learning progression means and if not, describe what you think a learning progression might be in as much detail as possible.

2. There are learning progressions for all disciplines. Science learning progressions are a bit different from others because these sequences are guided by empirical evidence collected and published then utilized to guide the sequence of the progression. Do you think this type of framework can be effective if implemented for all learning levels such as students from diverse cultures and English Language Learners? Please explain in detail.

3. What impact do you think a science learning progression will have on your current student population? Can you elaborate to include what you know about students’ learning levels, and special situations such as English Language Learners, and Special Education students?

4. Students are required to sit for a high stakes assessment at the end of this science course. Do you believe the science learning progression be used to ensure students are taught required concepts in preparation for this assessment? Please explain in detail.

5. Can you describe any formal education experiences where you were trained on the uses of multicultural education in the science classroom? Please explain in detail.

6. How important do you believe it is for teachers and administrators to be cognizant of diverse student cultures? How should this inform the way lessons are planned and implemented?

7. Please provide an example of how the use of cultural knowledge in a science classroom can increase student interest and engagement.
Post-implementation Interview (to be asked at the end of the study)

1. Can you describe in your own words what a science learning progression is? Please be as detailed as you can.

2. The science learning progression that was used to teach this unit was created using data and literature collected through empirical research. Do you believe this framework was effective for the various learners encountered? Please be as detailed as you can.

3. Taking all students into account, was this science learning progression useful for your student population? How was this framework different for English Language Learners and Special Education students (if applicable)? Was it advantageous or disadvantageous? Can you please give specific examples?

4. How useful was this framework in preparing your students for the high stakes assessment that they are required to take at the end of this course? Was it better than, the same as, or worse than previous pedagogical methods used? Please be detailed.

Additional questions for participant who implemented a SLP with CRP elements integrated.

5. Can you describe how you went about implementing the SLP with CRP elements integrated in your classroom? Please provide a summary of your procedures.

6. Taking all students into account, was this method useful for your student population? How was this framework different for English Language Learners and Special Education students (if applicable)? Was it advantageous or disadvantageous? Can you please give specific examples?

7. How useful was this framework in preparing your students for the high stakes assessment that they are required to take at the end of this course? Was it better than, the same as, or worse than previous pedagogical methods used? Please be detailed.
APPENDIX C: PROFESSIONAL DEVELOPMENT QUESTIONNAIRE FOR TEACHER PARTICIPANTS
1. Based on the information received in our sessions, describe your conceptual understanding of the theory behind science learning progressions and its uses in the classroom?

2. Please suggest one example of a possible lesson sequence that would align to a science LP. For instance, in a genetics unit that follows a LP format, what would be an example of the big idea, an essential question, and one student task?

3. How likely are you to employ the tenets of science learning progressions in your own lesson planning efforts? Please explain in detail.

4. Do you believe that this framework will change the way students learn science? How so?

5. In what ways can this presentation be enhanced to further encourage science teachers to utilize the framework in their pedagogical practice? Please suggest examples.

6. Based on information received in these sessions, please describe your conceptual understanding of what multicultural education is and how it might look in the classroom?

7. You examined a pre-created unit that combined CRP with a science LP unit. How confident are you that implementation of this unit in the classroom will be successful and how do you believe success can be measured without using students’ exam results?

8. Please suggest one example of a possible lesson sequence that would align to a science LP integrated with CRP. For instance, in a genetics unit that follows a LP format, how would you use cultural elements to engage students in the science you are trying to teach? Please be as specific as possible.

9. Do you believe integrating elements of CRP into a science LP sequence will change the way diverse students learn science? How so?

10. In what ways can this presentation be enhanced to further encourage science teachers to utilize these frameworks in their pedagogical practice? Please suggest examples.
APPENDIX D: QUOTES FROM RESEARCH STUDY ADULT PARTICIPANTS
<table>
<thead>
<tr>
<th>PARTICIPANTS</th>
<th>JM</th>
<th>CL</th>
<th>FB</th>
<th>Mr H</th>
<th>MP</th>
<th>AZ</th>
</tr>
</thead>
<tbody>
<tr>
<td>Familiarity with Learning Progressions</td>
<td>“I’ve never really heard the term…”</td>
<td>“…I don’t really know what a learning progression is.”</td>
<td>“…I don’t think I’m familiar with it.”</td>
<td>“A learning progression is…basically…determining where a student is, background knowledge, anything of that nature…”</td>
<td>“…I’m only recently familiar with learning progressions. They make sense.”</td>
<td>“…I Haven’t heard of it.”</td>
</tr>
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<td></td>
<td>“…if I learned it in Grad. School, I don’t remember hearing too much about it…so it wasn’t…major.”</td>
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<td>Postulated definition of learning progression based on prior knowledge and understanding</td>
<td>“…you’re learning in stages.”</td>
<td>“…it is the way you structure lessons…so there is a(n) organized, systematic way that you’re going through content and presenting it to students.”</td>
<td>“…I’m drawing on my literacy strategies of…putting the two things together. Learning progressions…identifying benchmarks over a period of time and trying to hit those learning benchmarks as you move along that continuum.”</td>
<td>it’s a concept that gets increasingly more complex over…a time period…”</td>
<td>“…in science it would be a concept that the students are expected to know or a skill they’re expected to be able to perform once they get to…12th grade, college ready…taking that concept…deconstructing it down to it’s most simple, basic, entry-level…can have access to the type of thinking…then progressively building up on that at each grade level.”</td>
<td>“…I’m just thinking…in terms of some things building on each other…you have to explore…you have to explain and then you have ask for the question.”</td>
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<td></td>
<td>“…by the end of the first grade…progress with that stage into second grade...build upon…into third grade.”</td>
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…”on a macro scale…students’ prior experiences frame their future experiences in the classroom.”
“...yes, I think it can be used for all...learning levels.”

“The only caveat I see is that somebody who’s new to our country may not have been in that progression and there’s some catch-up to do.”

“...I think it would probably be better suited to students who aren’t in the English Language Learner category...”

“...I don’t think (it) works as well in an environment...with students who are not as familiar with the specific...technical things for science because it’s not applicable for them in their lives...unless you make it applicable...”

“...I think it’s relevant in all subjects and I think it’s relevant especially in science.”

“...you must have certain benchmarks...prerequisites that students need to meet before they move on...”

“...it’s very relevant to all students regardless of their socioeconomic backgrounds...”

“...the (lessons) would have to be modified...for each student...”

“...especially with ELLs, I would use a lot of pictures...so they could have visualizations because sometimes it is disconnected...”

“...Yes, I believe it’s going to be utilized for any group on any level. Of course differentiation is required.”

“...a student from Dominican Republic...ask him about a volcano in Africa...he won’t know that background knowledge...”

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Impact of SLP on students

“...I don’t think it’s really about the IEP of the student. I think it’s about the history of the students again when we talk about ELLs, it really depends.”

“A Spanish-speaker who came from Spain has a totally different educational system that a Spanish-speaker who maybe from...Honduras...never went to school, versus Puerto Rico, which pretty much as a system like the United States.”

“...until you make it applicable to the kids...how they can relate to it and how they can see and even understand the very basic foundation of these scientific concepts...it can’t be applied to my students until those other things have happened.”

“...it’s not directly applicable until they have more of a foundation for their scientific skills, math skills, reading skills...”

“...our population...we do struggle; our students struggle to meet all of our State benchmarks, school benchmarks.”

“...I really think that if there are formalized benchmarks within the school here, students are going to struggle to get to those benchmarks.”

“...I anticipate...more students will fail...because they struggle.”

“...because of...very weak literacy skills, very weak numeracy skills.”

“...in terms of English Language Learners...whether they know is relative...we may be learning about animals that they have no idea (about)...they don’t have in their country or not familiar with it. The challenge...is that they are illiterate in their own language so (this)...poses a whole different challenge...”

“Sometimes it goes down to...teaching students to read...you have such a disparity...between what the ELLs have, Special Ed. students have...and what is)...required to get the information.”

“...There’s going to be different challenges.”

“Can it be done? Yes. Have I mastered it? No.

“...in my mind, within a particular school, if there are multiple science courses within different grade levels, the learning progressions would be really useful in vertical planning for science teams...teachers who teach similar content.”

“...skills-wide, it can be across different...courses...looking at science skills or...habits of mind...types of thinking...”

“...you would start with the end and...work backwards...as a team making sure that the foundations are provided for the students so it’s...successful when they get to...more advanced courses.”

“...in terms of my current students...it could be helpful...”

“...I think that in terms of my own students...they don’t have that skill...evidence into design...they are designing their own lab based on what they see.”

“...it could be a positive impact...my self-contained students...we have a lot of students who can’t read...or they’re ESL...anything could have an impact...”

“Sometimes...they don’t get it...because they are working with the language barrier and the learning disability.”
Use of SLP framework to teach curriculum to prepare students for high stakes assessments

“...I know it’s a high-stakes assessment but I don’t think it’s a high-cognitive assessment...it has changed so dramatically since I started teaching...I don’t know where the disconnect is.”

“Should we? Yeah probably.”

“Can we go directly to that right away? I think it would be difficult...”

“...we could start to incorporate it...”

“It would have to be...slowly easing into the science learning progression...to...present the concepts...to students.”

“So I know that we’re in a revolution where education is concerned, with rigor and the learning...to discover...but...we need to incorporate all these new learning strategies and all these new initiatives (in) preparing kids thoroughly for this exam.”

“...the truth is: doesn’t matter how beautiful students performance, no matter how well they enter debates and discussions. If they are unable to pass these exams, the data tells you that they’re failing.”

“Yes I do believe it can be used but I also think it can be very difficult.”

“I...believe standardized tests are biased and...almost impossible for students who really don’t know how to spell their names in some cases...”

“...the goal...should be to get everyone on the same page.”

“...it is unfair...to have ELLs...compete with those who are in other classes...because they don’t have the same background...because of the language barrier...are going to require more time to take in and learn information.”

“Yes.”

“The regents is not to test how well you know science. This is a test of how well you understand question style...it’s awful.”

“...as much as I hate this, the only way to prepare for the regents is by being exposed to the living environment regents questions.”

“...teaching the reading skills to be able to grasp, that’s something we don’t spend enough time on...that’s something that’s really hard to focus on cause you need to reform your entire year, not just a unit.”

“...I don’t think it would ensure success...”
I actually have not...not multicultural in the science classroom...

...I remember taking a class on multicultural learning...

Multiculturalism wasn’t really a thing in any of the classes I took.

There’s never...been too much...for how to...learn about their (students) cultures...how to...incorporate their cultures into curriculum...there’s never...been any formal training.

Everything I’ve learned...has been on-the-job...listening, talking to students.

...It has come up when...I was doing the Masters in ESL. We were talking about respecting different cultures and being...aware that you don’t misinterpret signals from different cultural groups...

...those were not a formal course, it was just in the context of learning about teaching students who don’t speak English.

There’ve been many strategies I’ve been taught to incorporate multicultural education...in the classroom.

It’s good to celebrate people’s culture...and...incorporate their culture into a lesson.

...that was a pretty big chunk of what we learned...how to take multicultural learning and implementation in classrooms.

...some people would argue culture has no place in the classroom. My philosophy is the opposite.

...students don’t care how much you know, until...they know how much you care and if we show them...they’ll be more willing.

...my...exposure to multicultural and...urban science education...came as a personal interest.

...in other graduate classes that I’ve taken, just about education systems...how to address these issues...special challenged faced by urban education...I’ve read articles and books related to that...

...I...developed...so many strategies just from Googling and looking at YouTube. I came across some really...cool thinkers who gave me...more insight and...more ideas for how to work with students in urban settings particularly in science.

...when I did graduate school, a lot of the classes had that kind of focus.

“...My advisor...she did a lot of things with bilingual education...and multicultural...I’m still learning with my students but that’s something I have been exposed to.”
Cognizant use of culturally relevant elements to plan units/lessons

“…the success of learning or…lack of success is not…a condition of the multicultural…students population.”

“I’ve seen Punjabi, Cantonese, Vietnamese, and yet these kids are scoring high…”

“…no matter where we come from is…how supported are we both at school and at home and what is the internal motivation of a child.”

“The politically correct answer is…if you worked in a city such as New York City, you’d be crazy not to consider it and not make more than an effort to know the students who are sitting in front of you.”

“‘Yes, we should be mindful of it (as we plan lessons and develop curriculum) but I don’t think that is what the curriculum should be centered on.’

“…the curriculum should be based on the content and the skills that every learner will need regardless of cultural background.”

“We need to…try to bring more of their culture as is relevant inside our lessons.”

“‘The knowledge of students is really important and particularly in science…(there are) misconceptions on the part of everyone…not just sub-groups of people.’

“‘Students have a chance to test some of their pre-conceived ideas that may or may not have been culturally informed but testing them will give them an opportunity to determine whether or not they are supported by actual evidence.’

“‘…if you’re not aware that students aren’t coming with the same level of vocabulary, the same exposure…’

“…if you’re not aware that students aren’t coming with the same level of vocabulary, the same exposure…water rafting is an example…if a student don’t know that water rafting is, they are not going to be able to relate to it.’

“…when you’re planning education, your lessons…even I know…we have to stop to translate the hard words, but not realizing which words are going to be hard for them.”
How to use culturally relevant pedagogy in the classroom (possible examples)

“...the thing with science is that it’s so universal”

“I’m sure that there’s countries that so many of our kids come from like West Africa...they have...NGO’s (Non-Governmental Organizations) over there who are...implementing...something as simple as...how they clean water. So...maybe a village or country that...they know of...their own village, it’d be even cooler. But that’s...working to try and improve the lives of the people there and...the science behind (it).”

“I’m seeing...this teacher...teaching this text set in the DR (Dominican Republic)...and the kids are on fire! Because most of our kids are Latino.”

“...they love it!...suddenly...the classroom now becomes yours.”

“I know the emotions, I know the food, I know the customs, I know the language.”

“It’s a completely different reality when kids can make that connection with (text)...to what they’re doing.”

“I hate to do this...incest is not frowned upon in all cultures. So if I was doing a lesson in genes, I would want to be...cautious not to look down or to make it look like I am...condemning that lifestyle which is a...to that lesson saying how this can cause these types of diseases and these types of issues.”

“...after watching a YouTube video of a science teacher from Maryland...where he took songs...students...will hear on the radio...he will get the instrumental track for it and replace it with science content that reinforce vocabulary.”

“I started using them and sharing them with other people and just seeing the students in classrooms, just the initial look on their face when they hear the beginning of the song.”

“So the other day, during the lesson...I thought about (this) like off the top of my head, we were talking about how metals are ductile...I was like: ‘Does anyone have earbuds?’...we talked about...the metals in the earbuds and nonmetals around it...’”

“...they were all excited because they all had them in their pockets...what excites them.”
APPENDIX E: REPRODUCTION UNIT ADAPTED FROM THE NEW VISIONS LIVING ENVIRONMENT CURRICULUM

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Unit Title:  
*Human Reproduction (Reproduction as Evidence for Evolution)*

Why do organisms have different types of reproductive strategies? How can comparing reproductive strategies provide us with evidence for the evolution of all life? How are humans uniquely suited for the reproductive demands of our species?

Reproduction and development are necessary for the continuation of any species, and as such all species have unique but related strategies for reproduction. In this unit, students learn about continuity and diversity of life in a variety organisms, including humans, and use their findings to discern evolutionary relationships. Exploring print texts, visuals, and hands-on experiences, students compare the mechanisms through which different living things reproduce, with a focus on comparisons to human reproduction.

**Enduring Understanding(s):**

- Cells make copies of their DNA and divide during growth, repair, and reproduction
- In sexual reproduction, organisms produce sex cells that contain half of the genetic information of the parent cell
- The development and health of a fetus is impacted by a variety of factors
- Organisms are both similar and different to one another, providing evidence of both common descent and adaptation environmental conditions

**Knowledge: Students will know…**

**High priority content - required**

- Mitosis and cell division/replication  
- Factors affecting reproduction and development  
- Asexual and sexual reproduction  
- Human adaptations and comparison to other species (asexual vs. sexual reproduction)  
(Std. 4, Key Idea 3, PI 3.1, Key Idea 4 - PI 4.1)

**Mid-priority content - recommended**

- Genetics of asexual vs. sexual reproduction  
(Std. 4, Key Idea 2, PI 2.1)

**Assessments**

**Summative Assessment - Performance Task**

How can we use evidence to identify and explain the evolutionary relationships between organisms? Create a cladogram that most accurately represents the evolutionary relationships between the organisms given. Use evidence from the unit to justify the choices made in your cladogram, including an explanation of why there are both similarities and differences across all of the organism.

**Summative Assessment - Regents Readiness**

Summative assessments for this unit may be made by using questions from prior-year regents examinations. Teacher will create assessments.

**Formative Assessments**

Throughout the unit, there are multiple moments for formative assessment. Formative assessment drives student learning in the 5E instructional approach. Teacher will use strategies such as questions, discussions, and writing samples to formatively assess.
PRIORITY STANDARDS

New York State Core Curriculum Standards Crosswalk - Living Environment
Key Idea 4: The continuity of life is sustained through reproduction and development
PI 4.1 - Explain how organisms, including humans, reproduce their own kind.
Key Idea 2: Organisms inherit genetic information in a variety of ways that result in continuity of structure and function between parents and offspring
PI 2.1 - Explain how the structure and replication of genetic material result in offspring that resemble their parents
Key Idea 3: Individual organisms and species change over time
PI 3.1 - Explain the mechanisms and patterns of evolution

Common Core Learning Standards - Science & Technical Subjects
CCSS.ELA-LITERACY.WHST.9-10.1
Write arguments focused on discipline-specific content.

LEARNING PLAN

Essential Questions:
- Why do organisms have different types of reproductive strategies?
- How can comparing reproductive strategies provide us with evidence for the evolution of all life?
- How are humans uniquely suited for the reproductive demands of our species?

Introduction to the Unit
- What are some similarities that you know between human reproduction and reproduction in other species? How can these similarities and differences provide insight into and evidence for evolutionary relationships? In this unit, students will explore human reproduction through the lens of comparative reproduction; gaining insight into the continuity of life and adaptative strategies. In this introduction, students will learn about the performance task, and begin to develop ideas that they will pursue over the course of the unit.
- Key Vocabulary List for Unit: Consider using this list to guide the Explain or Elaborate portions of the 5E plans, and use it as reference for student to student vocabulary based discussions.
APPENDIX F: NEW YORK STATE LIVING ENVIRONMENT CORE CURRICULUM,
STANDARD 4, KEY IDEA 4: REPRODUCTION²

Key Idea 4: The continuity of life is sustained through reproduction and development.

Species transcend individual life spans through reproduction. Asexual reproduction produces genetically identical offspring. Sexual reproduction produces offspring that have a combination of genes inherited from each parent's specialized sex cells (gametes). The processes of gamete production, fertilization, and development follow an orderly sequence of events. Zygotes contain all the information necessary for growth, development, and eventual reproduction of the organism. Development is a highly regulated process involving mitosis and differentiation. Reproduction and development are subject to environmental impact. Human development, birth, and aging should be viewed as a predictable pattern of events. Reproductive technology has medical, agricultural, and ecological applications.

Performance Indicator 4.1: Explain how organisms, including humans, reproduce their own kind.

Major Understandings:
4.1a Reproduction and development are necessary for the continuation of any species.
4.1b Some organisms reproduce asexually with all the genetic information coming from one parent. Other organisms reproduce sexually with half the genetic information typically contributed by each parent. Cloning is the production of identical genetic copies.
4.1c The processes of meiosis and fertilization are key to sexual reproduction in a wide variety of organisms. The process of meiosis results in the production of eggs and sperm which each contain half of the genetic information. During fertilization, gametes unite to form a zygote, which contains the complete genetic information for the offspring.
4.1d The zygote may divide by mitosis and differentiate to form the specialized cells, tissues, and organs of multicellular organisms.
4.1e Human reproduction and development are influenced by factors such as gene expression, hormones, and the environment. The reproductive cycle in both males and females is regulated by hormones such as testosterone, estrogen, and progesterone.
4.1f The structures and functions of the human female reproductive system, as in almost all other mammals, are designed to produce gametes in ovaries, allow for internal fertilization, support the internal development of the embryo and fetus in the uterus, and provide essential materials through the placenta, and nutrition through milk for the newborn.
4.1g The structures and functions of the human male reproductive system, as in other mammals, are designed to produce gametes in testes and make possible the delivery of these gametes for fertilization.
4.1h In humans, the embryonic development of essential organs occurs in early stages of pregnancy. The embryo may encounter risks from faults in its genes and from its mother's exposure to environmental factors such as inadequate diet, use of alcohol/drugs/tobacco, other toxins, or infections throughout her pregnancy.
APPENDIX G: REPRODUCTION UNIT WITH ELEMENTS OF CULTURALLY RELEVANT PEDAGOGY ADAPTED FROM THE NEW VISIONS ENVIRONMENT CURRICULUM AND INTEGRATED
Learning Progressions in Reproduction with elements of CRP: Teacher participant enacting this unit will use CRP assertions listed to prepare and execute lessons to multicultural students. Assertions are taken from, ‘A case for culturally relevant teaching in science education and lessons learned for teacher education,’ (Mensah, 2011).

CPR assertion 1: Before teachers can teach in culturally relevant ways, they will collaborate with others who come from diverse backgrounds in order to make connections and develop culturally relevant teaching practices with the ultimate goal of academic success of students and themselves.

CPR assertion 2: For teachers to be culturally relevant, they will have knowledge of and a firm grasp of language that will elicit student engagements and participation in learning science both formally (in school) and informally (at home). Teachers will successfully encourage students to make connections to science outside of the classroom (personal level). Science content taught will be academically beneficial but maintain cultural significance for students.

CPR assertion 3: In order for teachers to become culturally relevant pedagogues, they will be able to identify their own science identities including reasons for being science educators. They will be able to create culturally relevant lessons for diverse students and “develop a critical consciousness through which they challenge the status quo of the current social order” (Ladson-Billings, 1995a, p.160).

Unit Title:
*Human Reproduction (Reproduction as Evidence for Evolution)*

*Why do organisms have different types of reproductive strategies? How can comparing reproductive strategies provide us with evidence for the evolution of all life? How are humans uniquely suited for the reproductive demands of our species?*

Reproduction and development are necessary for the continuation of any species, and as such all species have unique but related strategies for reproduction. In this unit, students learn about
continuity and diversity of life in a variety organisms, including humans, and use their findings to discern evolutionary relationships. Exploring print texts, visuals, and hands-on experiences, students compare the mechanisms through which different living things reproduce, with a focus on comparisons to human reproduction.

Enduring Understanding(s):

- Cells make copies of their DNA and divide during growth, repair, and reproduction
- In sexual reproduction, organisms produce sex cells that contain half of the genetic information of the parent cell
- The development and health of a fetus is impacted by a variety of factors
- Organisms are both similar and different to one another, providing evidence of both common descent and adaptation environmental conditions

Knowledge: Students will know…

High priority content - required

- Mitosis and cell division/replication
- Factors affecting reproduction and development
- Asexual and sexual reproduction
- Human adaptations and comparison to other species (asexual vs. sexual reproduction)
(Std. 4, Key Idea 3, PI 3.1, Key Idea 4 - PI 4.1)

Mid-priority content - recommended

- Genetics of asexual vs. sexual reproduction
(Std. 4, Key Idea 2, PI 2.1)

Assessments

Summative Assessment - Performance Task
How can we use evidence to identify and explain the evolutionary relationships between organisms? Create a cladogram that most accurately represents the evolutionary relationships between the organisms given. Use evidence from the unit to justify the choices made in your cladogram, including an explanation of why there are both similarities and differences across all of the organism

Summative Assessment - Regents Readiness
Summative assessments for this unit may be made by using questions from prior-year regents examinations. Teacher will create assessments.

Formative Assessments
Throughout the unit, there are multiple moments for formative assessment. Formative assessment drives student learning in the 5E instructional approach. Teacher will use different types of formative assessments.

PRIORITY STANDARDS

New York State Core Curriculum Standards Crosswalk - Living Environment
Key Idea 4: The continuity of life is sustained through reproduction and development
PI 4.1 - Explain how organisms, including humans, reproduce their own kind.

Key Idea 2: Organisms inherit genetic information in a variety of ways that result in continuity of structure and function between parents and offspring
PI 2.1 - Explain how the structure and replication of genetic material result in offspring that resemble their parents

Key Idea 3: Individual organisms and species change over time
PI 3.1 - Explain the mechanisms and patterns of evolution
LEARNING PLAN

Essential Questions:

- Why do organisms have different types of reproductive strategies?
- How can comparing reproductive strategies provide us with evidence for the evolution of all life?
- How are humans uniquely suited for the reproductive demands of our species?

Introduction to the Unit

- What are some similarities that you know between human reproduction and reproduction in other species? How can these similarities and differences provide insight into and evidence for evolutionary relationships? In this unit, students will explore human reproduction through the lens of comparative reproduction; gaining insight into the continuity of life and adaptative strategies. In this introduction, students will learn about the performance task, and begin to develop ideas that they will pursue over the course of the unit.
- Key Vocabulary List for Unit: Consider using this list to guide the Explain or Elaborate portions of the 5E plans, and use it as reference for student to student vocabulary based discussions.
APPENDIX H: TEACHER PARTICIPANT’S UNIT PLAN
Unit Topic

- Reproduction as evidence for Evolution
  - Meiosis
  - Gamete Production and Fertilization
  - Comparative Embryology
  - Comparing Sexual and Asexual Reproduction

Unit Summary

Reproduction and development are necessary for the continuation of any species, and as such all species have unique but related strategies for reproduction. In this unit, students learn about continuity and diversity of life in a variety organisms, including humans, and use their findings to discern evolutionary relationships. Exploring print texts, visuals, and hands-on experiences, students compare the mechanisms through which different living things reproduce, with a focus on comparisons to human reproduction.

Stage 1: Desired Results

**Established Goals (Standards, etc.):**

<table>
<thead>
<tr>
<th>New York State Core Curriculum Standards</th>
<th>PI 2.1 Explain how the structure and replication of genetic material result in offspring that resemble their parents</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.1d In asexually reproducing organisms, all the genes come from a single parent. Asexually produced offspring are normally genetically identical to the parent.</td>
<td></td>
</tr>
<tr>
<td>2.1e In sexually reproducing organisms, the new individual receives half of the genetic information from its mother (via the egg) and half from its father (via the sperm). Sexually produced offspring often resemble, but are not identical to, either of their parents.</td>
<td></td>
</tr>
<tr>
<td>2.1j Offspring resemble their parents because they inherit similar genes that code for the production of proteins that form similar structures and perform similar functions.</td>
<td></td>
</tr>
<tr>
<td>2.1k The many body cells in an individual can be very different from one another, even though they are all descended from a single cell and thus have essentially identical genetic instructions. This is because different parts of these instructions are used in different types of cells, and are influenced by the cell's environment and past history.</td>
<td></td>
</tr>
</tbody>
</table>

**PI 4.1 - Explain how organisms, including humans, reproduce their own kind.**

4.1a Reproduction and development are necessary for the continuation of any species.

4.1b Some organisms reproduce asexually with all the genetic information coming from one parent. Other organisms reproduce sexually with half the genetic information typically contributed by each parent. Cloning is the production of identical genetic copies.

4.1d The zygote may divide by mitosis and differentiate to form the specialized cells, tissues, and organs of multicellular organisms.

4.1e Human reproduction and development are influenced by factors such as gene expression, hormones, and the environment. The reproductive cycle in both males and females is regulated by hormones such as testosterone, estrogen, and progesterone.

4.1f The structures and functions of the human female reproductive system, as in almost all other mammals, are designed to produce gametes in ovaries, allow for internal fertilization, support the internal development of the embryo and fetus in the,
uterus, and provide essential materials through the placenta, and nutrition through milk for the newborn.

4.1g The structures and functions of the human male reproductive system, as in other mammals, are designed to produce gametes in testes and make possible the delivery of these gametes for fertilization.

4.1h In humans, the embryonic development of essential organs occurs in early stages of pregnancy. The embryo may encounter risks from faults in its genes and from its mother’s exposure to environmental factors such as inadequate diet, use of alcohol/drugs/tobacco, other toxins, or infections throughout her pregnancy.

**PI 3.1 - Explain the mechanisms and patterns of evolution**

3.1g Some characteristics give individuals an advantage over others in surviving and reproducing, and the advantaged offspring, in turn, are more likely than others to survive and reproduce. The proportion of individuals that have advantageous characteristics will increase.

<table>
<thead>
<tr>
<th>Common Core Standards:</th>
<th>CCSS.ELA-LITERACY.WHST.9-10.1</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Write arguments focused on discipline-specific content.</td>
</tr>
</tbody>
</table>

**Stage 1: Desired Results continued…**

**Enduring Understandings (EUs)**: Students will know that...

- Cells make copies of their DNA and divide during growth, repair, and reproduction
- In sexual reproduction, organisms produce sex cells that contain half of the genetic information of the parent cell
- The development and health of a fetus is impacted by a variety of factors
- Organisms are both similar and different to one another, providing evidence of both common descent and adaptation environmental conditions

* Remember an EU is transferable to the discipline and can be addressed in a unit

**Essential Question(s) (EQs):**

- Why do organisms have different types of reproductive strategies?
- How can comparing reproductive strategies provide us with evidence for the evolution of all life?
- How are humans uniquely suited for the reproductive demands of our species?

**Knowledge, Skills, Vocabulary, and Misconceptions**

<table>
<thead>
<tr>
<th>Knowledge:</th>
<th>Skills:</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Knowledge: Students will know…</strong></td>
<td>SWBAT make comparisons and identify patterns</td>
</tr>
</tbody>
</table>

177
### High priority content
- Mitosis and cell division/replication
- Factors affecting reproduction and development
- Asexual and sexual reproduction
- Human adaptations and comparison to other species (asexual vs. sexual reproduction)

*(Std. 4, Key Idea 3, PI 3.1, Key Idea 4 - PI 4.1)*

### Mid-priority content
- Genetics of asexual vs. sexual reproduction

*(Std. 4, Key Idea 2, PI 2.1)*

### SWBAT
- SWBAT collect and analyze data to answer a research question
- SWBAT analyze sources of information and write claims based on those sources.
- SWBAT use evidence to justify a claim
- SWBAT compare and contrast structures
- SWBAT use diagrams to generate observations of biological processes
- SWBAT compare and contrast processes

### Enduring Key Terms/New Vocabulary
- meiosis
- mitosis
- differentiation
- gamete
- gonad
- ovary
- testes / testicle
- chromosome
- adaptation
- fertilization
- fallopian tube
- hormone / estrogen / testosterone
- ovulation
- embryo
- placenta
- common descent
- natural selection

### Misconceptions
**Misconceptions around plant reproduction:**
- Plants do not reproduce sexually
- Pollen in plants is unrelated to reproduction in humans
- Flowers are unrelated to reproduction

**Confusion around internal fertilization and internal development:**
- Humans and other animals that use internal fertilization do not come from eggs

**Clarifications**
- Plants use sexual reproduction. The pollen in plants are similar to the sperm in humans.
- Internal fertilization is when the egg is fertilized inside of the females body while external fertilization is when the egg is fertilized outside the body. Internal development is when the fertilized egg develops inside the body. So, all organisms use eggs. Fish use external fertilization. Humans use internal fertilization and internal development. Birds use internal fertilization but external development.
Meiosis: Comparing eggs across species
Do all species of animals use eggs to reproduce? What about plants? By exploring the processes that living things have in common, when it comes to formation of female gametes, students will learn about about common descent and evidence of evolution.

<table>
<thead>
<tr>
<th>Day</th>
<th>Content Objective</th>
<th>Skill Objective</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 Days</td>
<td>SWBAT explain prior knowledge about reproduction and the variety of ways in which organisms reproduce themselves</td>
<td>SWBAT make comparisons and identify patterns</td>
</tr>
<tr>
<td></td>
<td>SWBAT compare the structure and function of ova across a variety of species</td>
<td>SWBAT collect and analyze data to answer a research question</td>
</tr>
<tr>
<td></td>
<td>SWBAT explain that some similarities in reproductive strategies and structures is due to common descent</td>
<td></td>
</tr>
<tr>
<td></td>
<td>SWBAT to discuss environmental factors that may impact reproduction</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>SWBAT explain the function of meiosis in sexual reproduction</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>SWBAT explain why gametes are haploid while body cells are diploid</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>SWBAT state differences between egg and sperm, in terms of size and longevity.</strong></td>
<td></td>
</tr>
</tbody>
</table>

Gamete Production and Fertilization
Organisms that reproduce sexually need to have some mechanism for fertilization. In all species, the steps for fertilization are uniquely suited to the habitat, life cycle, and reproductive needs of the organism. By exploring the fertilization methods of different species, students will learn about the concept of and adaptation, and how adaptations provide evidence of common descent.
<table>
<thead>
<tr>
<th>Day</th>
<th>Content Objective</th>
<th>Skill Objective</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td><strong>SWBAT</strong> explain the role fertilization plays in sexual reproduction</td>
<td><strong>SWBAT</strong> analyze sources of information and write claims based on those sources.</td>
</tr>
<tr>
<td></td>
<td><strong>SWBAT</strong> explain the benefits of internal vs. external fertilization in different species.</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td><strong>SWBAT</strong> compare the human male and female reproductive structures to those in other species of plant and animal.</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>SWBAT</strong> identify the hormones involved in human reproduction.</td>
<td></td>
</tr>
</tbody>
</table>

**Comparative Embryology**

Commonalities in embryo development across vertebrates highlight evolutionary relationships and provide evidence for common descent. Human reproduction is highlighted in this sequence, and students explore the role of the placenta and how toxins may impact development.

<table>
<thead>
<tr>
<th>Day</th>
<th>Content Objective</th>
<th>Skill Objective</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td><strong>SWBAT</strong> explain the similarities among embryos from different species in terms of common descent.</td>
<td><strong>SWBAT</strong> use evidence to justify a claim</td>
</tr>
<tr>
<td></td>
<td><strong>SWBAT</strong> explain the role of the placenta in human fetal development</td>
<td><strong>SWBAT</strong> compare and contrast structures</td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>SWBAT</strong> use diagrams to generate observations of biological processes</td>
</tr>
<tr>
<td>1</td>
<td><strong>SWBAT</strong> explain how mitotic cell division results in identical genetic material in every cell in an organism’s body.</td>
<td></td>
</tr>
</tbody>
</table>

**Comparing Sexual and Asexual Reproduction**

<table>
<thead>
<tr>
<th>Day</th>
<th>Content Objective</th>
<th>Skill Objective</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td><strong>SWBAT</strong> explain the difference between sexual and asexual reproduction and the advantages and disadvantages of both reproductive strategies</td>
<td><strong>SWBAT</strong> compare and contrast processes</td>
</tr>
<tr>
<td>1</td>
<td><strong>SWBAT</strong> describe the steps involved in sexual reproduction</td>
<td></td>
</tr>
</tbody>
</table>
Performance Task:

The purpose of meiosis is ____________________________
__________________________________________________________________________________________

Egg cells of different types of species are similar because ____________________________
__________________________________________________________________________________________

Egg cells of different types of species are different because
__________________________________________________________________________________________

Some organisms have eggs that are more similar to each other because
__________________________________________________________________________________________

Some organisms have eggs that are more different to each other because
__________________________________________________________________________________________

The habitat of an organism is related to the structure of its egg because
__________________________________________________________________________________________

Describe and illustrate an example of what you described above:

The purpose of fertilization is ____________________________
__________________________________________________________________________________________
Fertilization in different types of species is similar because

Fertilization in different types of species is different because

Fertilization in some organisms is more similar to each other because

Fertilization in some organisms is more different to each other because

The habitat of an organism is related to fertilization because

Describe and illustrate an example of what you described above:

The purpose of embryological development is

Embryological development in different types of species is similar because

Embryological development in different types of species is different because
Embryological development in some organisms is more similar to each other because

____________________________________________________________________________________

Embryological development in some organisms is more different to each other because

____________________________________________________________________________________

Embryological development is a major proof of evolution because

____________________________________________________________________________________

Describe and illustrate an example of what you described above:

____________________________________________________________________________________

Group Discussion – as the people in your group are talking, take notes and respond

<table>
<thead>
<tr>
<th>Speaker 1:</th>
<th>Response to Speaker 1 (Questions, agree/disagree, make connections, note surprises and patterns)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Speaker 2:</td>
<td>Response to Speaker 2 (Questions, agree/disagree, make connections, note surprises and patterns)</td>
</tr>
<tr>
<td>Speaker 3:</td>
<td>Response to Speaker 3 (Questions, agree/disagree, make connections, note surprises and patterns)</td>
</tr>
<tr>
<td>Speaker 4:</td>
<td>Response to Speaker 4 (Questions, agree/disagree, make connections, note surprises and patterns)</td>
</tr>
</tbody>
</table>
What was similar about all of your answers? What patterns or vocabulary words kept coming up?

What differences were there in your answers? Did you disagree on anything?

Create a group summary that includes points from all of your individual summaries:

______________________________________________________________________________
______________________________________________________________________________
______________________________________________________________________________
______________________________________________________________________________
Illustration:

Teacher Feedback
Topic:

Illustration:

Peer assessment

<table>
<thead>
<tr>
<th>Topic:</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>What is the purpose/function?</td>
<td></td>
</tr>
<tr>
<td>How does the illustration/example demonstrate their summary?</td>
<td></td>
</tr>
<tr>
<td>Warm (good) feedback:</td>
<td></td>
</tr>
<tr>
<td>Cool feedback (how could they have improved?)</td>
<td></td>
</tr>
<tr>
<td>------------------------------------------------</td>
<td></td>
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</thead>
</table>

| Cool feedback (how could they have improved?) |
# Rubric for Reproduction Performance Assessment

<table>
<thead>
<tr>
<th></th>
<th>1 – Poor</th>
<th>2 – Mediocre</th>
<th>3 - Good</th>
<th>4 - Advanced</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Individual Summary</strong></td>
<td>Some questions are left blank. Most answers do not make sense</td>
<td>Every question is answered. Demonstrates effort but no thought</td>
<td>1 correct explanation is given for each question</td>
<td>Multiple explanations are given Demonstrates thought and effort</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Demonstrates neither thought nor effort</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Group Discussion</strong></td>
<td>There is no or little discussion</td>
<td>Most people in the group have equal contributions</td>
<td>Most people in the group have equal contributions Individual helps assure equal and thoughtful discussion by asking 1-2 question</td>
<td>All people in the group have equal contribution Individual helps assure equal and thoughtful discussion by asking at least 3 questions</td>
<td></td>
</tr>
<tr>
<td><strong>Participation</strong></td>
<td></td>
<td>Students just read off their answers without making comments or asking each other questions</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Group discussion</strong></td>
<td>Responses are not written for each group member</td>
<td>1-5 word response is given for each speaker</td>
<td>Minimal response is written for each speaker</td>
<td>Detailed response is written for each speaker. For example: I also wrote x, but I disagree about y. I am wondering what he meant when he said z.</td>
<td></td>
</tr>
<tr>
<td><strong>Notes</strong></td>
<td></td>
<td>For example: I agree with him</td>
<td>For example: I also wrote “blah blah blah.”</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Group Summary</strong></td>
<td>Summary is poorly written and incomplete</td>
<td>Summary is complete but does not flow well. It includes all information discussed</td>
<td>Summary is well developed and includes all information discussed.</td>
<td>Summary is well developed and includes all information discussed. There are no grammar or spelling mistakes.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Presentation</strong></td>
<td>Presentation is difficult to understand.</td>
<td>Presentation is coherent. Feedback is given to other presentations</td>
<td>Presentation is coherent and interesting. Detailed feedback is given to other presentations</td>
<td>Presentation is coherent and interesting. All members participate in presentation.</td>
<td></td>
</tr>
</tbody>
</table>