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The Graduate School

Department of Curriculum and Instruction

SUPPORTING PRE-SERVICE SCIENCE TEACHERS IN DEVELOPING CULTURALLY RELEVANT PEDAGOGY

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by

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To determine how effective science teacher certification programs are at supporting the development of culturally relevant pedagogy without an immersion aspect, two research questions were investigated:

1) How do pre-service science teachers view and design pedagogy while participating in an intervention designed to support the development of culturally relevant pedagogy?

2) How do pre-service science teachers view the importance of culturally relevant pedagogy for supporting student learning? How do their practices in the field change these initial views?
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For my family, who always believed in me;

For my committee, who were always there for me;

And for Scott, who never gave up on me.
Chapter 1 - Introduction

Introduction

“The quest for quality education is a part of the ongoing struggle faced by African Americans. Few, if any, teacher education programs design programs that expressly meet the needs of African American students. Although some teacher preparation programs are designed for “urban” education, the significance of African American culture rarely is a feature of such programs.”
Gloria Ladson-Billings (2000)

Researchers such as Ladson-Billings continue to investigate pedagogical strategies to support achievement for students from marginalized cultural groups (i.e. culturally relevant pedagogy). One part of the research base on culturally relevant pedagogy examines how teacher education programs prepare graduates for the potential challenges of teaching within culturally diverse classrooms. Predominantly, these teacher education programs use immersion to prepare graduates for teaching within culturally diverse classrooms. This study intends to build upon this research base by investigating a teacher education program that attempted to prepare graduates for teaching within culturally diverse settings without using an immersive component.

Background of the Problem

Persistent achievement gaps continue to prove that our society has fallen short in our pursuit of academic excellence for all students. This failure is not necessarily the result of ignorance or prejudice; rather, barriers for student learning arise when science teachers cannot relate to their students and effectively teach
science content. These barriers are caused by a number of factors, but one key problem is the existence of cultural differences between teacher and student:

“In teacher-student interactions, both teachers and students from diverse backgrounds bring with them ways of looking at the world representative of the environment in which they have been reared. These habits of mind or ways of knowing may or may not be compatible with scientific habits of mind or ways of knowing typically associated with scientific discourse... interactional patterns within a language and culture group may be incompatible with scientific practices as taught in the mainstream.” (O. Lee & Fradd, 1996)

While students within marginalized cultural groups may develop scientific understandings differently than their teacher, these understanding can be intellectually rigorous and produce scientifically sound practices (Warren, Ballenger, Ogonowski, Rosebery, & Hudicourt-Barnes, 2001). Science teachers that pass into an unfamiliar culturally setting may be unaware of how his or her patterns of knowing and learning differ from those of their students. This notion is known as culture shock (Sitten, 1976) and can be a challenge for science teachers when their students have developed understandings about the natural world through personal experiences filtered through an unfamiliar cultural lens (Okhee Lee, 2003). Student understandings may also become counterintuitive, as everyday understandings may not easily connect with scientific conceptions.

Many educational studies have investigated how cultural diversity affects classroom instruction (Atwater, Freeman, Butler, & Draper-Morris, 2010; George, 2005; Ladson-Billings, 2001; O. Lee & Fradd, 1996; Luft, Bragg, & Peters, 1999; Santamaria, 2009; Warren, et al., 2001). While studies on cultural diversity attest to the fact that teachers need to become familiarized with the cultural understandings of the students they teach, this is an ever-increasing challenge for novice science
teachers beginning their careers. Furthermore, students from marginalized cultural groups are commonly placed within the classrooms of novice science teachers (Clotfelter, Ladd, & Vigdor, 2005). As the student populations in the science classroom becomes increasingly linguistically and culturally diverse, it is imperative to establish a knowledge base that provides the necessary tools to teacher to allow for all students to achieve academically (Okhee Lee, 2003).

For the near future, the demographics of educators and the students they teach will continue to differ (Stanley & Brickhouse, 2001). According to the U.S. Department of Education (2008), 96.7% of the Public school teachers in Pennsylvania (out of 136,900) classify themselves as “White.” Take this in conjunction with the fact that only 80% of Pennsylvanian public school students classify themselves as “White,” and it implies that only 3.3% of our public school teachers have a common cultural background with the 20% of the students they teach. Dropout rates for students classified as “Black,” “Hispanic,” and "Native American" are significantly higher than the dropout rates for students classified as “White” (9.9%, 18.3%, 14.6% versus 4.8%, respectively). Given this trend, teacher certification programs are socially responsible for developing pre-service science teachers’ cultural sensitivity.

However, trying to influence pre-service science teachers’ cultural sensitivity is not a simple task. For example, culture is not easily defined to a specific setting (Hooker, 2003); while individuals from similar geographic locations may share similar cultural values, it is naïve to assume homogeneity across this community. Cultural identities vary between individuals: shared backgrounds and experiences
does not necessary imply similar cultural values. Factors such as socioeconomic status, religious background, race, and familial experiences contribute to an individual’s cultural identity. Science teachers must be prepared to develop pedagogy that acknowledges all of these cultural factors. While developing this pedagogy may appear impossible to achieve, successful pedagogical strategies have been identified that can assist pre-service science teachers beginning their career within culturally diverse classrooms.

Research suggests immersion programs are a necessary component for pre-service science teachers to understand how cultural understandings influence science instruction (Ladson-Billings, 1995). Immersion programs physically place pre-service science teachers into culturally diverse settings to provide authentic learning experiences. Immersion programs provide pre-service science teachers with a highly effective way to learn about cultural diversity; however, these programs have two major limitations to learning about cultural diversity. The first limitation is based on the previously mentioned difficulty in defining culture. Culture itself is a fluid entity: not easily defined for any one person, and even less so for a group of individuals. While immersing pre-service science teachers within culturally diverse communities help develop sociological knowledge of that specific community, that knowledge will not necessarily transfer to other culturally diverse communities.

The second limitation of immersion programs stems from having limited availability to culturally diverse populations. Geographically isolated universities that offer certification programs may not be able to provide opportunities for pre-
service science teachers to have an intensive immersion experience with diverse communities.

Previous educational research on cultural diversity and teacher certification programs focus primarily on the use of immersion programs (Ladson-Billings, 2000; Pedras, 1996; Rushton, 2001). This research study intends to fill this gap in the knowledge base by investigating how teacher certification programs can prepare graduates for the potential challenges of teaching within culturally diverse classrooms without immersing students into these settings.

**Research Focus**

Teacher certification programs need to ensure their graduates can be successful within culturally diverse classrooms. Science teacher educators must strive to ensure graduates are able to teach any and all students, regardless of how culturally diverse, how academically challenged, or how resistant to instruction the student is. Every student has the ability to succeed in science, and certification programs need to ensure their graduates have the tools necessary to support all students in science instruction. Retention rates of teachers within high-risk school districts are at lows as compared to other school districts, so it is clear that graduates intending to teach within these classrooms be provided more support in their methods coursework to held ease the transition.

A pilot study found that pre-service science teachers do acknowledge culture as an influence within the science classroom (Krajeski, 2012). This understanding provides a starting point for pre-service science teachers to become more engaged
in developing culturally relevant pedagogy. Pre-service science teachers understand that a student’s culture can either be supportive or a barrier to science instruction. However, more support must be given within educational coursework, as pre-service science teachers have difficulty in providing concrete ways to support these students, citing cosmetic changes instead of intensive revisions to the lesson itself (e.g. using alternative real life examples or lead-in activities for these settings, leaving the main structure of the lesson intact). The research presented here builds on the pilot study, by examining the impact of an intervention that supports pre-service science teachers to think critically about the choices they make in the science classroom impact student learning.

The trends discussed above highlight the need to better support pre-service science teachers in developing culturally relevant pedagogy. However, how can science teacher certification programs support pre-service science teachers without having access to culturally diverse settings? Interventions need to be developed within science methods coursework that can provide this much needed support. In order to do so, research that has investigated culturally relevant pedagogy needs to be overviewed to provide insight on this issue.

A near-authentic intervention was developed at a geographically isolated university in order to prepare pre-service science teachers for the potential challenges of teaching culturally diverse classrooms. This was accomplished through support in: developing teaching strategies based on successful practices in science education; using assessment strategies and self-reflection to modify
instruction to better suit the needs of the students; and using examples of culturally relevant pedagogy to critically think about its impact on science education.

Research Design

This study employed a case study methodology to investigate a near-authentic intervention program designed to support the development of culturally relevant pedagogy and its impact on pre-service science teachers’ notions of culturally relevant pedagogy. The unit of analysis for this study was the discourse of pre-service science teachers enrolled in a second semester science methods course, which was the site of the intervention program. Data for this study was collected from videos of classroom observations, audio recordings of personal interviews, and artifacts created by the pre-service science teachers during the class.

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2) How do pre-service science teachers view the importance of culturally relevant pedagogy for supporting student learning? How do their practices in the field change these initial views?
In the next chapter, a theoretical framework is grounded in relevant educational research, including an overview of the science teacher knowledge base, how science educators learn how to teach, and the theoretical underpinnings for culturally relevant pedagogy.

The methodology for this study is described in chapter three, including the relevant research on qualitative methods and case study methodology. Data collection methods and a coding framework are also presented within this chapter. Chapter four contains an analysis of the data, presenting the overall findings for the study, along with the data that supports these claims. Finally, chapter five discusses how these findings contribute to current educational research on culturally relevant pedagogy. Future directions for this research are also discussed.
Chapter 2 – Theoretical Framework

Introduction

This chapter presents an overview of the educational research used to build a theoretical framework to ground this research study. To begin this chapter, research on how science teachers learn is discussed. Sociocultural theory (Vygotsky, 1978) is used to frame the situated learning (Lave & Wenger, 1991) and cognitive apprenticeship (Collins, 2005) models of learning. Next, the kinds of knowledge science teachers need to learn is discussed, identifying the science teacher knowledge base needed for science teachers to become highly effective at developing sound pedagogy. Of particular interest within the science teacher knowledge base is sociocultural knowledge, as helping pre-service science teachers develop this knowledge is the focus for this research study. After this, research on how to teach diverse students is discussed, examining techniques successfully implemented within culturally diverse classrooms. These techniques include reflection strategies used to modify pedagogy, which I see as an entrée or gateway into more sophisticated strategies, and the theoretical underpinnings of culturally relevant pedagogy. Finally, using the framework of how science teachers learn, the knowledge science teachers need to learn, and how to teach diverse students, in the subsequent chapter I present a near-authentic intervention program, embedded in a science teacher education course, designed to support pre-service science teachers in developing culturally relevant pedagogy.
**How Science Teachers Learn**

**Sociocultural Approach**

As a founder of sociocultural learning theory, Lev Vygotsky (1978) posited that individuals first learn through social contexts, specifically he stated that:

“Every function in the child's cultural development appears twice: first, on the social level, and later, on the individual level; first, between people (interpsychological), and then inside the child (intrapsychological).” (p 57)

While children work within social contexts, Vygotsky argued that children form their own understandings through mediated activities. Mediated activities are situated within the specific social contexts in which the learning occurs. As children engage in these mediated activities, certain objects and actions emerge with special meaning. Vygotsky defines these meanings as signs and tools. Signs can be objects or actions that a child places meaning on beyond its physical properties. Examples of signs Vygotsky mentions are tying a string around your finger to remember something important or marking notches on a wooden stick as a primitive way to keep records, receipts, or monetary obligations. Tools are similar to signs in that they also emerge within mediated activities; however, they differ as tools are used to teach specific content. Tools help a child form understandings within specific social contexts. Language is an example of a tool as it is used to communicate and understand one another. Vygotsky’s sociocultural learning theory was used as the foundation for the development of the situated learning theory.

According to Lave and Wenger (1991), learning is embedded within the social setting in which it occurs. They describe all learning as “situated learning,” as it is an inseparable connection between what a learner understands and where that
knowledge is acquired. This implies that learning is not a decontextualized process, but rather occurs while participating in the social and cultural influences within a learning environment. It should be clarified that these social and cultural influences need not be designed specifically to facilitate learning, but rather that it is impossible to separate learning from these physical and social environments.

Building on Vygotsky’s work, situated learning links cognitive processes with the social practices through which learning takes place. The situative perspective is not explicitly intended to clarify what educational practices would be best in any given context. Instead, it is a model that is used to analyze and clarify how learners interact with and acquire knowledge. Situated models of learning point educators to the need to recognize that learning takes place not only in the classroom, but also in informal contexts such as the home and the social activities that learners engage in.

With this in mind, educators must support practices of inquiry and sense-making for students by providing multiple learning contexts for the learners to participate in social discourse (Greeno, 2005).

**Cognitive Apprenticeship**

Learning takes place within multiple social and cultural environments; however, without providing a clear learning focus, learners may not benefit from an activity. Therefore, it becomes prudent to have an “expert” in the field of study guide learners towards understanding. There is a long history of teaching and learning has often taking place through the pairing with an expert in an apprenticeship. While this traditionally concerns manual skills such as carpentry or painting, Collins talk
suggested there as analogs with more cognitive or abstract skills and knowledge, what he described as “cognitive apprenticeship” (Collins, 2005). Cognitive apprenticeship involve engaging learners with authentic activities, mediated through social constructs that closely resemble those of practitioners of the field, that acculturate learners into the field, in my case pre-service science teachers into science education (Brown, Collins, & Duguid, 1989). While this model draws on historical practices of education (e.g. children learned how to grow crops, construct furniture, and make clothes through pairing with an expert), this pattern is prevalent in current approaches to education due to the value of providing an expert in the field of study for learners (Collins, 2005). While science teacher certification programs may vary in requirements, a universal aspect of all of these programs is that the pre-service teacher are placed within a school and paired with a mentor teacher. Authentic environments provide valuable learning experiences for pre-service teachers, though only when accompanied with preparatory coursework that prepare pre-service teachers for the rigors of teaching.

Cognitive Apprenticeship: Authentic Activity

The cognitive apprenticeship model states that learning requires engaging in authentic activities that reflect practices of science (Collins, 2005). Any activity that takes place within a learning environment is contextualized by the culture of the learning environment. As with any situated learning, an activity's meaning and purpose is defined by the social discourse between learners and educators in the context of their interaction. An activity is most useful for learning a discipline if it
takes place within a social context that closely resembles the activities of which experts in the field engage. When this happens, the activity may become coherent, meaningful, and purposeful for the learner; or, in other words, this activity becomes authentic. An authentic activity is defined as the ordinary practices of a culture that take place within the appropriate social context (Brown, et al., 1989). This is a restrictive view of authentic activity, as it calls into question the ability of science teachers to support student learning without being able to engage students in the authentic practices of science. Not only is it difficult for science teachers to model authentic practices of scientists within the classroom, but also it is unlikely these students would have the appropriate prior knowledge necessary to engage in all of these practices. As such, this previous definition of authenticity can be expanded to include both authentic learning and authentic science.

McDonald and Songer (2008) suggest that teaching science has at least two dimensions of authenticity: authentic learning and authentic science. Authentic learning is “the degree to which the teacher focuses enactment around students’ pursuit of personally or locally relevant content” (p 986). Authentic science, on the other hand, is the “degree to which the teacher focuses enactment on the development of students' understandings of and participation in the unique culture and practices of science” (p 986). These two dimensions tend to become muddled and confused within other literature. McDonald and Songer state that authentic learning deals with the issue of control in the classroom, whether that control is held primarily by the educator or by the learner. Authentic science, rather, deals
with the activity itself, and whether that activity is more or less like the activities that scientists in the field perform.

Pre-service science teachers must consider authenticity of both kinds and need to become familiar with successful pedagogical strategies informed by current research in science education designed to support both responsive teaching and scientifically rigorous practices. Situated approaches to learning suggest that science lessons must be authentic, and so the tools the teacher uses within the classroom must be modeled in such a way to support student controlled activities that support real science practices. Brown, et al. (1989) argue that most of school work is inauthentic, and therefore not fully productive of useful learning. This view on authenticity is very restrictive and thus renders the role of the science educator difficult. Cognitive apprenticeship tends to focus on authentic science without acknowledging the benefits and necessity of authentic learning. Activities are rarely defined as either “authentic” or “non-authentic;” rather, they tend to fall along a spectrum of authenticity. For example, one could argue that, within pre-service science teacher programs, reading about science teaching techniques is “non-authentic,” while student teaching is an “authentic” activity. If this were the case, then how would a peer teaching activity in a science methods course be defined? If compared to reading about science teaching, a peer-teaching activity would be defined as “authentic.” However, when compared to student teaching, this classification becomes much less clear. If both peer teaching and student teaching were defined as “authentic,” that would imply that both have the same potential for supporting learning in authentic ways. This is simply not true; pre-service science
teachers have the opportunity to learn more within their student teaching 
experience than from any previous “mock” teaching activity; however, without 
scaffolding PSSTs with activities such as peer teaching, the PSST will be unprepared to deal with the rigorous demands of student teaching.

Many of the activities that PSSTs engage in during their methods coursework would not be classified as authentic in the strict sense; however, these activities still model many of the responsibilities that practicing teachers are faced with on a daily basis. For example, both PSSTs and practicing teachers are required to develop unit and lesson plans. The difference between these activities would be that practicing teachers develop unit and lesson plans for a specific audience (i.e. their K-12 classroom), while PSSTs imagine a classrooms full of students when they develop their unit and lesson plans. Another example of this would be the peer-teaching activity, where PSSTs are asked to teach a science lesson for their classmates. Again, this mimics the responsibilities of practicing teachers, with the only difference being the audience (i.e. K-12 students vs. peers). In these cases, when a PSST mimics the responsibilities of a practicing teacher, with the only exception being displaced from a K-12 classroom, I suggest the description “near-authentic.” These “near-authentic” activities can help support PSSTs in developing the skills necessary to become highly effective teachers by scaffolding their experiences.

Cognitive Apprenticeship: Scaffolding

Collins (2005) defines scaffolding as a support system that provides learners with assistance in performing learning objectives. Scaffolding can be presented in
many different forms (e.g. highly constrained tasks, guided help when a learner is confused about the material, hints about how to proceed with the activity). One way that scaffolding can structure an activity is by ignoring low-level tasks, such as arithmetic calculations, so that the learner can concentrate fully on the high-level tasks. Another way to scaffold an activity is by focusing solely on the low-level tasks initially, and then by gradually increasing the difficulty until the learner is able to perform all of the tasks without assistance. Scaffolding is a method that supports learners to carry out tasks that are currently beyond their capability.

Authentic activities can be scaffolded within pre-service science teacher programs. For example, with the exception of student teaching, pre-service science teachers have very little “authentic” experience in teaching according to a strict interpretation of Brown’s definition. However, this is not a drawback to the program, but rather provides an opportunity to scaffold PSSTs into the rigors of teaching science. Within methods courses, PSSTs learn about a plethora of topic areas, such as: developing lesson and unit plans, supporting diversity within the classroom, and supporting English language learners, alongside many other topics. One activity that many PSSTs engage in is teaching a science lesson to their classmates (i.e. peer teaching). This activity ignores a substantial portion of actual classroom teaching, as the lesson: (a) has little need to attend to classroom management issues that would otherwise be significant within K-12 classrooms; and (b) many within the class will already be familiar with the content being presented during the lesson. However, peer teaching can scaffold PSSTs in developing and teaching their science lessons within supported conditions. In this
way, PSSTs can work on aspects of practice without having to worry about the entire practice; then, when adequately prepared, these PSSTs learn how to modify their lessons to fit the needs of their K-12 classroom. Science methods courses should be designed to support PSSTs in developing the fundamentals of science teaching without overwhelming these novices.

**Conclusion**

Learning is not an individual activity, but rather is derived while participating in the social and cultural context contained within a learning environment. Authentic activity and scaffolding are necessary tools for supporting learning within science teacher education programs. Sociocultural models can help teacher educators understand how students learn how to teach. While it is important to understand how PSSTs learn to teach, it is just as important to understand what specific kinds of knowledge PSSTs need to learn in order to teach. Science teachers must possess a fundamental knowledge base in order to effectively teach within a diversity of social contexts.

**What Science Teachers Need to Learn**

Science teachers must possess the appropriate knowledge base to effectively teach science. This includes both knowledge of the science content and knowledge of how their students learn. Collins (2005) states that there are four dimensions of knowledge that must be considered within a cognitive apprenticeship model of learning. These four dimensions of knowledge are (pp 49-53): (1) “Content
knowledge,” the knowledge of “the concepts, facts, and procedures explicitly identified with a particular subject matter”; (2) “Method Knowledge,” the knowledge of how “to observe, engage in, and invent or discover expert strategies in context”; (3) “Sequencing Knowledge,” the knowledge of how “to order learning activities”; and (4) “Sociological knowledge,” the knowledge of the “social characteristics of learning environments.”

While each of these dimensions of knowledge are critical components of the cognitive apprenticeship model, I will focus on sociological knowledge as pertinent to this investigation. The purpose for this research study was to understand how science teachers develop pedagogy to support culturally diverse groups of students. As stated previously within chapter one, sociological knowledge is an undervalued component of the science teacher knowledge base. Therefore, sociological knowledge will be examined further to understand how this dimension of the science teacher knowledge base is a critical component needed for teaching within culturally diverse settings.

**Sociological Knowledge**

Sociological knowledge is a critical component of the science teacher knowledge base, as it helps to develop pedagogy based on the cultural understandings of the classroom. Culture can be difficult to construct and define, as it is a dynamic and complex idea that is used in many disciplines. While culture can be sometimes be categorized by an individual’s race, gender, and social status, these characteristics are not the sole determination of culture. Spradley (1972) defines
culture as “the acquired knowledge people use to interpret experience and generate behavior” (p 6). Smith-Maddox (1998) states that culture involves “not only everyday practices (patterns of discrete behaviors, traditions, habits, or customs) but also the way that people understand ideas and ascribe meaning to everyday life” (p 304). Erickson (1997) contextualizes his definition of culture to within the classroom:

“Culture, as it is more or less visible and invisible to its users, is profoundly involved in the processes and contents of education. Culture shapes and is shaped by the learning and teaching that happen during the practical conduct of daily life within all the educational settings we encounter as learning environments throughout the human life span, in families, in school classrooms, in community setting, and in the workplace. Educators address these issues every time they teach and every time they design curriculum. They may be addressed by educators explicitly and within the conscious awareness, or they may be addressed implicitly and outside conscious awareness. But, at every momentum the conduct of educational practice, cultural issues and choices are at stake.” (pp 33-34)

These definitions guided how culture was conceptualized in this study and suggested how its influences everyday practices.

Cultural diversity is defined as "the existence of a variety of cultural or ethnic groups within a society" ("Oxford Dictionaries," 2014). Within the context of this study, I intend to expand this definition of cultural diversity to also include instances where only the culture of the teacher and the culture of the students are dissimilar. While instances such as these have little cultural diversity (i.e. two cultures: that of the teacher and that of the students), they contribute to understanding the impact of cultural differences on instruction. Therefore, when I mention “culturally diverse” populations, I also refer to “culturally diverse or dissimilar” populations.

The value of sociological knowledge is highlighted in the Teachers for a New Area Initiative (Kirby, McCombs, Barney, & Naftel, 2006) as they bring attention to
the importance of cultural considerations and minority recruitment. Given the current demographics of our public school students, pre-service science teachers must, at the very least, be taught basic elements of the cultures in which their future students live in. These cultural boundaries can either help or hinder science learning, and if teachers are ill prepared to handle these cultural differences in the classroom, minority students may be turned off of science altogether. While in-service induction programs can help support new science teachers, pre-service coursework must prepare science teachers’ understandings of cultural boundaries to avoid forcing a sink-or-swim methodology on new teachers already hindered by the responsibilities of their first year of teaching.

While changing the science curriculum to be more culturally sensitive can help students from disenfranchised and underrepresented groups feel better included in their educational experience, some researchers are skeptical about whether this will have any effect on reducing the intolerance groups harbor towards each other (Diner, 1993). Intolerance is not necessarily born from a lack of information, but instead may reflect more structural inequities within the social and economic climate that foster harsh resentment between groups with different amounts of power. This attention to the needs of underrepresented groups and the power differentials in society at large are an outgrowth of critical race theory. To understand the importance of sociological knowledge to science teachers it is important to understand the roots of theories’ attention to race.

**Critical Race Theory**
Critical race theory was first introduced in the 1960s to challenge the practical functions of a legal system significantly impacted by racial issues in society. It is based upon the principles that: racism is deeply embedded within the legal, cultural, and psychological U.S. society; racism crosses epistemological boundaries; racism deters civil rights laws that are often undermined before implementation; racism uses the self-interests of the upper class that claim neutrality, color blindness, and objectivity as deterrents to serious reflection on the problems facing this society; and racism neglects a thorough examination of the historical implications of law and society (Chapman, 2011, p 220).

On of the first instance of the application of critical race theory in education (or perhaps, the most famous) came from the Brown v. Board of Education trial in Topeka, Kansas. With increasing achievement gaps between Black and White children, policymakers increased their efforts on developing policies that focus on socio-economic strategies (Chapman, 2011). While these efforts were a step in the right direction, the strategies largely ignored the interconnections between race and class. Martin Luther King Jr.’s famous words of judging a man by his character and not by the color of his skin have been misinterpreted by teachers, who tend to confuse what it means to treat each child equally and what it means to teach each child equally (Chapman, 2011).

All students bring their own ways of knowing into the classroom, and it is naïve to believe specific instructional strategies can be universally effective. If educators fail to acknowledge the culturally based understandings of their students, we run the risk of alienating students from scientific careers who could be great
assets to the field with their unique approaches to the world. The general strategies within our educational system do not take into consideration the complex interactions between race, class, culture, and language; furthermore, this system ignores the issues of racism, White privilege, White dominance, and social class dominance (Zion & Blanchett, 2011).

It is in our nation’s best interests to ensure that a substantial population of students are not failed by our educational system (Zion & Blanchett, 2011). Within the social foundations of education, Chapman (2011) proposes many ways in which critical race theory can help shape current policy. First, it can explore how significant social events shaped educational policy based on discriminatory practices. Second, it can analyze how different societies were able to partner with educational professionals in order to provide the best education for our children. Finally, it helps to reflect upon our current educational strategies and determine whether our practices are equitable. It is this last use of critical race theory that is relevant to this study.

**Cultural Influences on Learning Science**

Critical Race Theory has had impact on a variety of subfields in education and has contributed to a movement toward the consideration of culture in learning. Science educators must be aware of how the cultural understandings of their students can be both barriers and resources to learning science. Students involved in scientific activity will not necessarily make identical observations or express their understandings in similar ways. In addition, the scientific discourse learners engage
When discussing scientific ideas is far more important than the observation itself. Scientific definitions are not fixed, and the relationship between a phenomenon and its scientific explanation is especially complicated by learner’s prior understandings. And finally, the language used to describe reality can be interpreted differently by multiple individuals during engagement in discourse (Milne & Taylor, 1998).

Ignoring the cultural aspect of science can be a costly mistake. Science is a culture, or set of cultural practices in its own right, and any classroom discussion within science becomes a cultural activity (Milne & Taylor, 1998). When learners are familiar with scientific thinking, these discussions may overlook the cultural aspect of this type of discourse; however, when attempting a discussion within culturally diverse settings, it becomes clear how culture plays a role in learning science. The teacher departs from the role of authoritarian and distributor of knowledge, and instead supports a discourse among the students on what constitutes scientific knowledge (Carter, Larke, Singleton-Taylor, & Santos, 2003). This provides students a feeling of ownership of their scientific knowledge, which can be done by studying real phenomenon and relating the learning in the science classroom to wider societal and technological issues (Webster, 1997). However, such discourse practices are difficult for teachers unfamiliar with their students’ cultural understandings, particularly in cases involving students of marginalized cultural background. Investigations into children’s learning in science suggest that children of marginalized cultural backgrounds interpret scientific concepts differently than the normative science point of view (Snively & Corsiglia, 2001). Teachers need to develop a cultural sensitivity towards their curriculum, especially
in contexts where the community is situated in an area with strongly non-dominant local culture.

McKinley (2001) questions whether changing the science curriculum to be more cultural sensitive is necessary, and suggests any interaction can be handled by simply determining where the student’s learning difficulty lies and working out the most effective solution for supporting that student. According to McKinley, this strategy works universally, whether the issue lies in cultural differences, racial differences, gender differences, or even just a general misunderstanding of the subject matter. Furthermore, McKinley suggests that the adoption of culturally sensitive strategies has done little to change White teachers’ views of their Asian and Black students capacity for achievement being linked to their cultural background. In addition, if White teachers can learn and adequately understand the cultural backgrounds of their students, there is little need for having diversity in the teacher population (McKinley, 2001). This, however, provides a very pessimistic view of cultural diversity in science education. Highly qualified science teachers, regardless of cultural background, will always be needed in our K-12 classrooms. Given the same situation, a more optimistic view would argue that if White science teachers can learn about and understand the cultural backgrounds of their students, this in turn will allow them to support their non-White students to become scientists and science educators themselves, thus increasing the cultural diversity of our teacher population.

All educators, but in particular White teachers, are in need of multicultural education. If White teachers cannot be trained to become culturally sensitive, then
there is little hope for them to improve the educational attainment of the diverse students in their classrooms. Furthermore, as cultural differences exist even within subcultures, even White teachers working with all White students can benefit from a multicultural viewpoint (Stanley & Brickhouse, 2001). We must develop appropriate ways of supporting all our teachers in developing cultural sensitivity if we hope to overcome historical inequities in science education and to support children from all backgrounds have the potential to learn science (National Research Council, 2007).

Understanding the culture of students is not an easy task, as it is based upon a wide range of variables including (but not limited to) race, socio-economic status, religious affiliations, and nationality. A teacher who is proficient at teaching science to students in a particular urban school district does not necessarily guarantee that teacher would be able to teach students in another urban school district. Diner (1993) cautions teachers that it borders on racism and sexism to assume that all individuals of the same gender/race/cultural origin think and act in the same manner. Generalizing culture-based research to larger populations is difficult due to the complexity in classifying an individual’s cultural identity in a singular way.

To address this difficulty, it is clear that pre-service science teachers must understand the foundations of developing culturally relevant pedagogy. While providing pre-service science teachers with authentic experiences in culturally diverse settings is effective, two main issues stem from this approach. First, not all universities will have access to diverse cultural settings to provide authentic activities for PSSTs. Second, cultural identities within K-12 schools are unique to
specific settings and should not be assumed to be common among across locales, socio-economic status, or racial diversity.

**How to Teach Culturally Diverse Students**

In 1991, the National Science Teachers Association directly addressed the need to help all students achieve in science, regardless of race, gender, or socioeconomic status. They state that quality science education must be accessible and provide knowledge and opportunities to all individuals. In addition, the science curriculum must reflect cultural diversity and historical contributions. Also, science teachers must, at the very least, be aware of variations across learning due to culture. And finally, science teachers are responsible to encourage all children to pursue careers in science (Carter, et al., 2003).

Taking these as the goals are for a successful graduate of a culturally sensitive pre-service science teacher education program, the question then becomes how to best achieve these goals. This can be a difficult task for educational programs that do not have the resources to really immerse pre-service science teachers within the authentic contexts. For example, Ladson-Billings (2001) describes her Urban Teacher Academy (UTA), a theoretical school that would be a perfect example of how to produce Culturally Relevant Teachers. The UTA would be located in a major university located within an urban setting, having affiliations with a small number of urban schools willing to work with the university. Admission to the program would be competitive, taking only the best candidates based on prior teaching experience, commitment to public service organizations, and academic achievement. Students
enrolled in the program would partner with the local community, becoming involved with local churches, neighborhood health centers, or child-care agencies. Students would also be placed to live with a family in the school community for a brief time period in order to immerse them with the local practices, norms and values. The coursework would be a blend of observing and assisting in the classroom while taking educational classes towards certification. This fictitious school, while being applauded for its progressiveness, would not be a realistic option for most science education programs in the United States, as they do not have access to the urban schools required to make it a reality. A more feasible approach would be to prepare teachers to be culturally relevant by drawing on other instructional and contextual practices.

A common theme in the literature is that to teach PSSTs about diversity education, immersion in the field is the primary, and in some cases only, factor in appropriately preparing teachers for equitable education. Bianchini and Brenner (2010) investigated how an induction program supported and constrained pre-service teachers efforts to teach science or mathematics in effective and equitable ways. Equitable instruction, as defined by Bianchini and Brenner, involves starting instruction from students’ lives, developing strategies that work for English Language Learners (if they are present), providing differentiated instruction that does not reduce the level of content but rather changes the pace or type of instruction to better suit the needs of all students, and implementing inquiry-based practices in science that make connections between the student, their society, and integrated technology. Their study found that the two beginning teachers, Emily and
Kristen, found their previous teacher education experiences focused on ESL instruction and participation in their current school communities were the main contributing factors in how they learned to teach in culturally relevant ways. The induction program itself had little effect on the change in viewpoints on culturally sensitive teaching. Interestingly, the study found that both teachers felt confident in ESL instruction due to their coursework with SDAIE, which provided instructional strategies for English learners. This was due to the coursework adopting a narrow focus on what teachers need most rather than a large breadth of content with little depth. They conclude that that teachers need to develop an understanding of students’ out-of-school context and how it’s situated within the community in order to develop culturally relevant approaches to teaching.

This poses a problem for science teacher education programs. As highlighted previously, it is crucial for science educators to be able to understand and relate to the heterogeneous cultural climate of learners within the social constructs of the learning environment. In addition, the most effective way of learning about students’ culture is by immersing oneself into diverse social contexts. With this in mind, it becomes problematic to try and prepare pre-service science teachers to be able to teach in all possible culturally diverse settings when pre-service science teachers may have differing plans post-graduation that will take them to a multitude of cultural and social environments. The question then becomes, is it as important for pre-service science teachers to learn about the culture of the students they may teach one day, or instead, to focus on how pre-service science teachers can learn how to learn about the culture of the students they will teach one day? How can pre-
service teacher education programs support their students in developing culturally relevant pedagogy when access to culturally diverse classrooms is limited or even impossible? And how can teacher education program prepare PSSTs for the variety of possible contexts in which they may teach in the future?

Culturally Relevant Pedagogy

Within our educational system, teachers must deal with social issues in addition to their regular, instructional goals. These issues may stem from race, socioeconomic status, and gender, among many others (Ladson-Billings, 2001). It is clear that approaches must be developed within teacher education courses to help ease beginning teachers into thinking critically about the content they want to teach and how best to teach it to diverse populations. In order to minimize the potential culture shock pre-service science teachers may experience within diverse cultural settings, a framework for culturally relevant pedagogy will be useful.

To create an effective pedagogical practice, teachers need to form a theoretical model addressing student achievement while reaffirming students’ own cultural identities from a critical perspective. This perspective should challenge inequities within the scientific field. This approach has been described as a culturally relevant pedagogy (Ladson-Billings, 1995).

Culturally relevant pedagogy is based on three broad propositions (p. 478): (1) “The conceptions of self and others held by culturally relevant teachers”; (2) “The manner in which social relations are structured by culturally relevant teachers”; and (3) “The conceptions of knowledge held by culturally relevant
teachers” (Ladson-Billings, 1995). Culturally relevant pedagogy, while relatively recently characterized in this way, is not all that new of a concept. Equality in education can be traced as far back as the late 1960s during the equal rights movement (Diner, 1993).

Within culturally relevant pedagogy, teachers must maintain fluid student-teacher relationships, develop a rapport with their students, foster a shared community of learning, and encourage their students to collaborate. These practices, however, may be more academic than pragmatic. That poses an interesting question: Can a culturally insensitive teacher, within certain settings, be labeled as a “good” teacher? For example, can a teacher be placed in Classroom A, where the students share a similar social and cultural background with the teacher, have their teaching classified as “high-quality”; whereas, if the same teacher is placed in Classroom B, with a diverse set of students or even a homogenous group that with a social and cultural background significantly different than the teacher, would the teacher still be labeled as excellent? To answer that question requires unpacking what qualities and characteristics are exhibited in Culturally Relevant Teachers and compare those characteristics to the general characteristics of teacher education graduates. These characteristics can be categorized in three overarching categories: Indicators of Academic Achievement, Indicators of Cultural Competence, and Indicators of Sociopolitical Consciousness (Ladson-Billings, 2001).

*Academic Achievement*
When stepping into the classroom, a Culturally Relevant Teacher must assume all students have the capacity to learn. Even for struggling students, the Culturally Relevant Teacher needs to adjust lessons to ensure success for all students. Culturally Relevant Teachers must clearly state what the requirements for achievement are so students know exactly what success entails. In a science classroom, the Culturally Relevant Teacher (CRT) knows the appropriate scientific content and how to teach that content to the learner; in other words, the CRT knows the content knowledge, the pedagogical knowledge, and the pedagogical content knowledge relevant to what they are trying to teach. In addition, the CRT must adopt a critical stance towards the curriculum and evaluate it in terms of how effective it is for his or her own students. And finally, in terms of academic achievement, the CRT must adopt multiple methods of measurement to test student learning and allow multiple opportunities for academic success (Ladson-Billings, 2001).

Cultural Competence

Helping students value their own cultural backgrounds is not an easy task for teachers, as teachers may not be aware of their own culture and the role it plays within society. Those that are White rarely even recognize the benefits belonging to their culture, a system of privilege and power. For the CRT, they understand how culture plays a role in education. CRT can recognize their own personal cultural perspectives and biases and how it can affect their lives and the lives of their students. The CRT takes responsibility for making an effort to learn about their
students’ culture and community and recognize it is not option, but a requirement, to make the extra effort to bridge the divide between the school and the students’ homes. CRTs use their students’ culture as a grounding point for lessons and incorporate students’ prior knowledge, not as a barrier to learning, but as valuable resources for promoting the learning process. And finally, the CRT know and make use of the multiple cultural identities of their students (Ladson-Billings, 2001).

Sociopolitical Consciousness

The Culturally Relevant Teacher understands the sociopolitical interactions that exist between the school, the local community, the scientific community, and the nation as a whole. The CRT must be able to acknowledge and expose themselves to the realities beyond what appears in newspapers and on television. The CRT must be an agent for public good, valuing their students for who they are and how they can be a positive influence on the world long after graduation. The CRT not only teaches the content, but also tries to develop students’ critical thinking skills and how classroom practices can be applied outside contexts. And finally, the CRT recognizes that students’ success in the classroom will have consequences for the quality of their lives. The CRT must make an investment in the students’ futures and not fall back on disclaimers such as “It’s not my fault if you don’t do the work” or “I get paid whether you pass or fail” (Ladson-Billings, 2001).

Conclusion
Culturally relevant pedagogy provides an answer for how to teach culturally diverse students. To develop culturally relevant pedagogy, teachers must assume that all students can achieve academically, teachers must value and connect to the culture of their students, and teachers must possess a sociopolitical consciousness towards the many social contexts their students engage in. If culturally relevant pedagogy helps support the needs of culturally diverse students, then research on how to support teachers in developing culturally relevant pedagogy must be explored.

**Supporting Teachers in Developing Culturally Relevant Pedagogy**

Immersion programs are highly effective at supporting pre-service science teachers in developing culturally relevant pedagogy (Ladson-Billings, 2001). However, not all teacher certification programs have access to the culturally diverse school settings necessary for immersion programs. If teacher certification programs wish to prepare pre-service science teachers for culturally diverse science classrooms, the ways in which science teachers are successful within these settings must be identified. The foundations for culturally relevant pedagogy provide a framework for teacher certification programs to implement intervention programs designed to support pre-service science teachers to succeed within culturally diverse settings. The theoretical underpinnings of culturally relevant pedagogy are based on three propositions: teachers must assume that all students can achieve academically, teachers must value and connect to the culture of their students, and
teachers must possess a sociopolitical consciousness towards the many social contexts their students engage in (Ladson-Billings, 2001).

Up until now, the discussion of Culturally Relevant Pedagogy has dealt primarily with changing teacher attitudes and beliefs about achievement in the science classroom. Clearly, it is imperative that science teachers possess the appropriate mindset when dealing with culturally diverse populations. Without this mindset, educational biases will fester within the classroom, providing advantages to those that can relate to or are members of the culture of the teacher in the classroom. For science teachers to be able to work with diverse learners, extra time and effort needs to be put toward examining multiple approaches, strategies, and experiences that will help reach children with multiple modes of transition, in addition to teachers being able to examine their beliefs about teacher and learning (Goodnough, 2010). To be clear, preparing pre-service science teachers does not imply that each child receives an individual program of instruction. Children are asked to participate in a variety of tasks best suited to diversity of cognitive and cultural strengths in a variety of activity structures (e.g. small group instruction, whole-class presentations, and assessment activities) (Goodnough, 2010).

In this section, I present a near-authentic intervention program focusing on transitional strategies designed to improve the ability of pre-service science teachers to support the needs of culturally diverse students, without necessitating an immersion in a diverse classroom. Research-based strategies that focus on supporting diverse learners can help scaffold PSSTs and act as a sort of gateway into their understandings of cultural influences on science education. These strategies
provide a scaffold for PSSTs to understand and develop culturally relevant pedagogy in a context where they do not have access to diverse field experiences.

**Supporting Diverse Learners**

Research-based strategies such as assessment, reflection, and adaptation can help pre-service science teachers support all students to achieve academically and begin to help them understand how to support a diverse group of learners. These teaching strategies include using alternative forms of assessment to measure success, reflecting on educational strategies to improve one’s own practices, modifying pedagogy based on results from those assessment, and reflection strategies to better support the needs of students (Gardner, 1993).

**Assessment**

Using alternative forms of assessment is a key strategy that can be used when developing pedagogy. Gardner (1993) stresses the importance of using assessment strategies that look at both the working styles of a student in addition to the student’s intellectual capacity. Gardner defines working styles as:

“...the way a child interacts with the materials of a content area, such as ability to plan an activity and to reflect on a task, and level of persistence.” (p 89)

Gardner stresses the need for teachers to devise assessment strategies that focus on the student’s process of learning, rather than the specific outcome, in order to understand how to develop pedagogy that can support all students in learning.
Tomlinson (2005) states that teachers must ensure every student feels safe within his or her own learning environment. Lessons must include clear learning goals, and assessment must be done on a regular basis, not only to gauge student understanding, but also to guide classroom instruction. Teachers must be flexible and responsive to the needs of the students, rotating between whole class, small group, and individual instruction. In doing this, both the student and the teacher will be able to work towards a common interest in learning and respect for one another.

Reflection

Considering how students learn is an organizational structure that can support the needs of a variety of students (Goodnough, 2010). Reflection becomes a key component in teacher preparation programs, asking PSST to reflect upon their experiences and what changes they see fit to improve the lesson. Huebner (2010) suggests that teachers need to focus on the core ideas of the lesson, acknowledge student differences and group students based on shared interests, take care in assigning on meaningful assignments, and continually assess while reflecting on classroom instruction.

Gardner (1993) recognizes the need for teachers to reflect upon their lessons. These reflection strategies include the ability to assess one’s own pedagogical practices, to be able to take on the role of a critic, and propose suggestions to improve these practices to better support the needs of all students. Assessment is a critical tool to use within self-reflection, as it provides a guide for teachers to understand the strengths (and weaknesses) of students. Teachers that
use proper assessment techniques are able to critically self-reflect and determine if they must modify their pedagogical practices.

Adaptation

As discussed previously, pre-service science teachers tend to teach content the way they were taught during their own school experience. This tends to limit the ability of pre-service science teachers to be able to reach out to learners within diverse classrooms. Teachers that start their careers within culturally diverse classrooms need to become responsive to the needs of these students. Students learn content in a variety of different ways, and it is important for teachers to modify their own practices based on the needs of the students to help students develop subject-matter competencies (McTighe & Brown, 2005). To be able to adapt teaching to the students in the class is key to working with diverse populations, and supporting adaptation can be done within pre-service science teacher education programs.

In order to do this pre-service science teachers must be challenged to engage students with content in multiple ways, thinking about how to use various activity structures, incorporate technology into their lessons appropriately, and present content objectives in multiple ways. Pre-service teachers should become familiarized with a variety of activity structures, such as the Predict-Observe-Explain model and Problem-Based Learning. They should be familiar with how technology can be used to help enhance the teaching of science concepts. Pre-service science teachers should be able to think about how instruction may be
modified or changed based on the demographics of the class (e.g. academically diverse students, co-ed versus all female students, rural versus urban). And finally, pre-service teachers will need to create multiple lesson plans, having the same content objectives but with significantly different lesson approaches to content learning opportunities.

Suggestions for modifying pedagogy to support diverse learners contain strategies that parallel the development of culturally relevant pedagogy. In order to do so, PSSTs must be given tools that allow them to reform their practices away from a one-size-fits-all format. While modifying pedagogy to support diverse learners requires PSSTs adapting to the diverse needs of students academically, developing culturally relevant pedagogy requires PSSTs adapting to the diverse needs of students culturally. Atweh and Abadi (2012) recognize the importance of considering the cultural understandings of the surrounding community when developing pedagogy. The practices around modifying pedagogy to support diverse learners can scaffold PSSTs thinking about modifying pedagogy based on the cultural diversity of their students by drawing on notions of diversity PSSTs are more familiar with (i.e. academically diverse classroom) to a less familiar culturally diverse classroom. Reflection, adaptation, and assessment are core strategies needed to support student understanding, and translating these strategies to consider a wider sense of diversity can also help as PSSTs begin to understand culturally relevant pedagogy.

Developing Culturally Relevant Pedagogy
In developing culturally relevant pedagogy, it is essential for teachers to consider the prior knowledge of their students and how those students conceptualize the scientific phenomenon they are learning. Effective assessment strategies are critical to being able to gauge students’ actually understanding of complex scientific ideas and practices. Therefore, pre-service science teachers require support in different types of assessment and how to best use those strategies.

Assessment can take many different forms and can be both formal and informal. Pre-service science teachers should be aware that assessment is not limited to only to the most immediate examples that come to mind - tests and quizzes. One example of the assessments pre-service science teachers could become familiar with is the conceptual interview. Conceptual interviews are particularly powerful in pre-service teacher contexts, where they can be asked to conduct conceptual interviews during their field experience with a diverse group of children. In addition to this, PSST need to develop a well-rounded assessment strategy by trying out new approaches during more controlled teaching opportunities, such as during peer teaching experiences. Reflecting on how assessment impacts their understanding of their students and their abilities is an important experiences for beginning teachers as it pushes them to recognize that one assessment can not give them all the information they need to support their students.

Pre-service science teachers need to be exposed to current culturally relevant pedagogy as part of their preparation. While it has been established that particular culturally relevant pedagogies are most relevant to the specific setting
they are developed within, pre-service science teachers should be given the opportunity to explore some examples of culturally relevant pedagogy, through designed experiences such as: peer teaching, lesson design, assessment design, and teaching CRP lessons while in their field experience.

One support mechanism that can be useful is exploring websites and resources pertaining to culturally relevant pedagogy that are available online. Some of these resources have video examples of classroom teaching within multiple cultural contexts, and it can be helpful for students to watch, reflect, and discuss these videos as a class. It can also help for students to begin to think critically about possible intuitions and misconceptions about the impact of culture on learning within their content area. These intuitions and misconceptions may be specific to certain cultural contexts; for example, how the topic of evolution may be viewed by Southern Baptists, or how the idea of Climate Change may be viewed differently within various socio-economic groupings. These ideas can be discussed throughout the semester within the classroom to better support the development of pre-service science teachers’ understandings of culturally relevant pedagogy.

**Conclusion**

Many issues arise when considering cultural influences within science education. While students are judged on the amount of scientific knowledge they possess, science education is not simply about the acquisition of knowledge, but rather critically evaluating that knowledge and the processes involved in its creation. Students possess their own ways of understanding the natural world that
draw on their own experiences and culture, and science educators can ill-afford
dismiss these cultural understandings. Current reform efforts in science education
have made great strides towards identifying the need to support all students, as the
Next Generation Science Standards (NGSS Lead States, 2013) identify key strategies
teachers can use to support diverse student groups. Strategies such as using
culturally relevant pedagogy to support students from major racial and ethnic
groups or identifying “connections and disconnections between home/community
and classroom/school” (Appendix D, p 6) to support economically disadvantaged
groups were identified within seven case studies involving diverse student groups.
Equity in science education Equity in science education can be achieved by
approaching science learning as a cultural process (Quinn, Schweingruber, & Keller,
2012). All students have the potential to succeed in learning science; teachers must
be familiar with strategies such as culturally relevant pedagogy so that they can
effectively support this potential.

Culturally relevant pedagogy gives science educators a framework for
supporting the needs of culturally diverse students within the classroom. While
immersion programs can be highly effective at supporting science teachers in
understanding cultural diversity, not all teacher certification programs have access
to culturally diverse settings. This challenges teacher preparation programs to
provide pre-service science teachers with other experiences and teaching contexts
where they can develop the skills necessary to engage in culturally relevant
pedagogy without benefit of immersion. In the next chapter, I discuss the
investigation of a course, and the specific experiences within the course, designed to
support PSSTs initial understandings of CRP. I describe this “near-authentic” intervention program that draws specifically on pedagogical techniques to modify pedagogy as a gateway set of practices into Culturally Relevant Pedagogy.
Chapter 3 – Methodology

Culturally relevant pedagogy (CRP) is highly effective at supporting the needs of culturally diverse students within science classrooms (Ladson-Billings, 2001; Lee, Deaktor, Enders, & Lambert, 2008; Matsko & Hammerness, 2014; Patchen & Cox-Petersen, 2008; Powell, 1997). Universities that offer science teacher certification programs should provide opportunities for pre-service science teachers to develop a working knowledge of CRP. This requires familiarizing pre-service science teachers with the societal needs of underrepresented minorities, acquainting pre-service science teachers with the theoretical framework for CRP, and providing practical teaching experiences working with diverse science populations. Graduates from science education certification programs should have the appropriate knowledge to teach at all schools, regardless of how culturally diverse the students are in such schools.

However, just as some K-12 schools have limited access to the ideal tools that are helpful in teaching science, some universities do not have access to the ideal experiences useful in supporting pre-service science teachers in developing CRP. These issues may stem from the university having little to no access to culturally diverse K-12 schools for field experience. In addition, having access to culturally diverse settings does not necessarily provide pre-service science teachers with the skills needed to develop culturally relevant pedagogy; pre-service science teachers need to be familiarized with the theoretical underpinnings of culturally relevant pedagogy so that they can develop CRP within any culturally diverse classroom. These universities require innovations in teacher education programs to prepare
their pre-service science teachers for the challenges and opportunities of cultural diversity without using immersion programs.

This study intends to investigate how pre-service science teachers, without access to culturally diverse science classrooms, engage in a near-authentic intervention program designed to support the development of culturally relevant pedagogy. Two research questions were developed to investigate this issue:

1) How do pre-service science teachers view and design pedagogy while participating in an intervention designed to support the development of culturally relevant pedagogy?

2) How do pre-service science teachers view the importance of culturally relevant pedagogy for supporting student learning? How do their practices in the field change these initial views?

**Investigating the Issue through Qualitative Means**

This study investigates how effective a university with little racial diversity can support pre-service science teachers (PSSTs) in developing culturally relevant pedagogy (CRP) through their participation in near-authentic activities. One way to examine this issue is to focus on a particular case of PSSTs going through their methods coursework. Below, I argue a qualitative study was best suited to investigate all of the nuances of these questions, as a qualitative analysis provides the tools necessary to gain a deeper level understanding of how PSSTs make decisions about how to approach culture in the classroom.
Qualitative research has the ability to critically analyze phenomenon and provide insight into understanding. Maxwell (2005) lists eight goals that qualitative research seeks to do. Five of these goals, in particular, are pertinent to this research study: (1) Qualitative research can help researchers understand the actions, events, and experiences of a select population; (2) Qualitative research can help researchers understand the deeper situative context of a select populations’ actions and influences on these actions; (3) Qualitative research can help researchers develop causal explanations on observed events; (4 & 5) Qualitative research can help improve existing practices by providing suggestions based on the results of the study while also engaging the intellectual community with further insight on these practices.

One key aspect of this research study is that I had to analyze the actions PSSTs made while participating within this intervention program (Goal 1 – Qualitative research can help researchers understand the actions, events, and experiences of a select population). Some of these actions included statements that PSSTs made regarding CRP. In addition, these PSSTs developed artifacts such as unit plans and discussion blogs that needed to be analyzed. However, to perform a deep analysis of this data, making observations of these actions was not sufficient. I needed to both observe the actions of the PSSTs while also determining whether these actions possessed deeper meaning (Goal 2 – Qualitative research can help researchers understand the deeper situative context of a select populations’ actions and influences on these actions).
There were many influences on the actions of these PSSTs, such as prior experiences learning science or directly from participating in this intervention, and these influences needed to be identified. Part of this research included time where the PSSTs worked at secondary schools for six weeks. While there, I discovered whether participating in the intervention program had an influence on the actions of these PSSTs (Goal 3 – Qualitative research can help researchers develop causal explanations on observed events). And finally, the primary intent of developing this intervention program was to discover whether it could support PSSTs in developing CRP without having access to diverse classrooms. If successful, this intervention could be implemented within other certification programs to help the development of CRP. In addition, these findings could provide the intellectual community with contradictory results about the development of CRP, as many studies cited in the literature review state that the only way to support the development of CRP is to immerse PSSTs in culturally diverse classrooms (Goal 4 & 5 – Qualitative research can help improve existing practices by providing suggestions based on the results of the study while also engaging the intellectual community with further insight on these practices). For these reasons, I used a qualitative methodology to give insight into answering this study’s research questions.

**Defining Case Study Research**

Through a case study methodology, this study sought to investigate how pre-service science teachers develop culturally relevant pedagogy. Case studies answer the “how” and “why” types of research questions, focus on contemporary events,
and require no behavioral control over the participants. The research questions for this study required more than just determining whether this intervention program was successful or not. This study needed to be analyzed much deeper by determining specific reasons for success, or failure, for this specific case of pre-service science teachers participating in a near-authentic intervention program designed to support the development of culturally relevant pedagogy without access to diverse settings.

As the primary instructor for this teaching methods course, I exerted a large amount of influence over the activity of these PSSTs. This influence was intentional, as the intervention was dedicated to improving their knowledge of pedagogy and CRP in particular. However, for the purposes of research, it was critical not to place any undue influence over any of the PSSTs that could bias the results of this study. For example, interviews with PSSTs were conducted by a separate individual so that the interviewees could feel comfortable answering truthfully. In addition, while analyzing the data, I was cautious to examine my own potential bias towards the success of this intervention. Though there were some limitations due to unavoidable influences, I designed this study to have a minimal amount of influence over the PSSTs in the context as a researcher. When starting this research, I first defined my procedures before investigating. These procedures are outlined in further detail below. It was important for me to develop a clear set of procedures before I attempted this study, as not doing so would create an unsatisfactory research study that yielded biased results.
Yin (2003) defines case studies as empirical inquiries that investigate contemporary phenomena within its real-life context that is useful when the boundaries between the phenomena and the context are not evident or easily separable. Yin states that case studies become a detailed examination of one setting, one subject, or one event; in this case, I examined the actions of PSSTs. Case studies can vary in their complexity, though researchers should be cautious if using multisite or multisubject studies, as these may make it difficult to find a clear focus of study (Bogdan & Biklen, 2007). As such, I kept the focus of study narrow, as this research study investigated a single case with multiple participants: PSSTs’ participation in a near authentic intervention program designed to support the development of culturally relevant pedagogy.

Some researchers, however, argue that case studies are not a methodological choice so to speak, but rather a choice on what is to be studied (Stake, 2005). This conflicts with Yin’s definition of case study research, as Yin classifies case study research as a methodological design. However, Stake also mentions that case studies are valuable for their contributions to refining theories. He mentions that case studies illuminate a decision, or set of decisions, why they were taken, how they were implemented, and with what result. While I disagree with Stake’s claim that case studies are not a methodological choice, his statements about the contributions of case study research were helpful to consider during the design process of this study.

Case studies are a descriptive analysis of one or more individuals, within a specific setting, that tries to give insight into a phenomenon that takes place. While I
specifically focused on a single case (i.e. the pre-service science teacher), I had multiple participants, as there were many PSSTs that participated in this intervention program. When performing case study research, it is helpful to consider the generalizability or transferability of the study, as drawing conclusions that only apply among sparse settings will not be helpful to advance educational research (Bogdan & Biklen, 2007). While limitations exist within all research studies, which I acknowledge within this study, I argue that my analysis provided important insights into PSSTs’ decision-making processes when designing CRP. Furthermore, these insights have implications for other science teacher education programs, as similarities exist within both the context of this research study and other science teacher education programs.

When choosing to employ a case study methodology, researchers must use detailed and appropriate methods to justify their findings. When case study researchers are sloppy or careless they can allow their own prejudices to influence their findings (Strauss, 1987). For this case study, I took many precautions in order to ensure this research was academic and valid (Yin, 2003). This included providing a detailed description of the coding framework used to analyze the data. In addition, I was careful when making any claims within the analysis, and only did so when there were multiple instances of supporting evidence. By taking a thoughtful approach to the design of this study, I was able to ensure that these research questions could be answered through appropriate means.

Case study researchers must also consider the generalizability of their findings. Generalizability can be a difficult goal to achieve in case study research, as
there is no clear set of guidelines that researchers can use. However, it can be done if the researcher considers: (a) how unique the participants in the study are; (b) how the researcher sampled participants from a subject pool; and (c) how unique the phenomenon is being studied (Yin, 2003). Having generalized results, though, can be a double-edged sword. On one hand, research findings will hardly make an impact on the field of research if it only applies to a small set of the population. On the other hand, research findings that are generalized to larger populations may tend to become diluted and have little meaning. It is interesting to note that, while the populations being studied and the theories based on those populations are separate entities, they are still intertwined. As studying a portion of the population generates theory, that theory in return informs how the larger population functions. Thus, it was important that I balance the two, trying to apply research findings to larger populations without losing the original intent. Other case study researchers instead use transferability when presenting their findings. Transferability, as opposed to generalizability, does not attempt to make broad claims based on larger populations. Instead, researchers present their findings as being limited to the population being studied, but in addition those findings can provide direction and questions for other researchers to study within similar populations. I based my analysis on the frameworks used by other researchers that study CRP, and I make connections between the findings from my research and the findings from other studies. By grounding a case study approach with related research, a strong argument can be made for generalizing to a theory based on those findings.
Case study researchers must also consider sampling methods as it can affect generalizability or transferability. Researchers must be clear on how participants for the study were chosen. As a researcher, I had to define the characteristics of the specific case and make an argument that this is a common factor found most everywhere. Using Yates (2004) framework, I had to consider the following when sampling: which people, groups, or organizations the hypothesis for this study applies to; the availability of these cases, as not all will be practical to study; and a method of sampling that produced the most representative sample. In essence, I needed to choose a sample that would help understand how CRP is developed when there is little to no access to culturally diverse settings. Specific criteria were identified when choosing this sample, such as its limited access to diverse classrooms, their practical experience working with secondary schools during the methods course, and the opportunity to integrate this near-authentic intervention program into the curriculum.

In addition, keeping a fair balance and variety within the sampling is just as important as selecting a sample based on attributes. Yates (2004) states that there are two different types of sampling procedures: purposive and probability. With purposive sampling, the researcher decides, within the research guidelines of how the study should be conducted, which subjects will be selected for the study. This can be a homogenous sample (“a narrow range based upon only one factor”), a structural sample (“a set of related categories”), a heterogenous sample (“based on a broad range of categories”), or a quota sample (“representatively structured version of a heterogeneous sample”). In probability sampling, the researcher, after defining
a subject pool that meets the requirements of the study, selects participants solely at random. This sampling can be simple random (“all cases have an equal probability of being selected”), systematic sample (“every nth case is selected, starting with a specific case”), stratified or structured random (similar to the simple random method, but “the population is subdivided according to a set of categories, with cases proportionally selected at random from the subdivisions”), or a cluster sample (“cases chosen from randomly selected ‘areas’ related to some variable”). I overview my sampling method later in this chapter, alongside my reasoning, but a cluster sample was used for this case study.

One final caution when employing a case study methodology is that researchers must avoid overly extended time frames that result in massive collections of field notes (Yin, 2003). For this study, I chose an appropriate time frame for conducting this research that included sufficient time to collect all the data necessary to answer these research questions. While I collected a substantial amount of data, the scope of the data collection was purposefully limited in order to provide a detailed analysis.

**Case Study - Conclusion**

Certain distinctive features of case study research emerge when considering how case studies should be conducted. The first feature of case study research is in the types of research questions asked. As Yin (2003) stated, case study research is designed to answer the “how” and the “why” of activities. To answer these types of questions brings about the second feature of case study research, its data collection
methods. While some of these studies might have supplemented their research with quantitative data (e.g. surveys, questionnaires), a common theme is that they all observed the specific activity directly and interviewed selected individuals about their impressions on the activity. The third feature arises from properly grounding the observations. Into any activity, each individual brings in his or her own prior experiences and cultural heritage. To further complicate this matter, researchers also bring their prior experiences and cultural heritage to the situation. In order to compensate for this, I included my interpretive biography within this chapter so that the reader could understand any unintentional bias. Researchers, such as me, must be very explicit in describing both the context of their subjects and the context of the researcher.

The final feature of case study research lies in its conclusions and generalizability or transferability. While researchers may be hesitant to expand their findings to a larger scale, a strong case can be argued that these findings are not an uncommon occurrence. One way to do this is to ensure that the literature review includes relevant research related to the study. While a singular case study holds little weight in the research community, presenting it alongside similar studies can make significant advancements to the field.

This study will be a single case study with multiple participants, investigating pre-service science teachers’ understandings about the role of culture in the classroom and how those understandings may change by engaging in near authentic experiences. Before attempting such research, it was important to detail how typical
case studies are performed. Now the details of this case study research can be addressed.

**Data Collection**

The research questions for this study are:

1) How do pre-service science teachers view and design pedagogy while participating in an intervention designed to support the development of culturally relevant pedagogy?

2) How do pre-service science teachers view the importance of culturally relevant pedagogy for supporting student learning? How do their practices in the field change these initial views?

To answer these questions, I examined how pre-service science teachers view the role of culture in the classroom. In addition, I determined whether these pre-service science teachers were adequately prepared to teach in diverse classrooms. While the preparedness of these PSSTs was not directly observed, as this study did not collect data from PSSTs teaching in diverse classrooms, I make the case the attitudes and actions of these PSSTs during their methods coursework are indicative of an orientation towards being able to successfully develop culturally relevant pedagogy.

As mentioned previously, I employed a case study methodology to properly answer these research questions. This study was a single case study with multiple participants. To be able to properly answer these questions, I argue that it is important to collect data that consists of: video recordings of classroom activities;
audio recordings of personal interviews; and artifacts generated by the PSSTs within the classroom.

Video recordings of classroom activities were useful in determining how pre-service science teachers view of the role of culture in the classroom and their preparedness to teach within culturally diverse classrooms. These video recordings were important to collect for four reasons. First, as the PSSTs participated in many different activities during the intervention, video recordings of these activities were essential sources of data. The PSSTs performed multiple tasks during the intervention, in particular discussions about culturally relevant pedagogy. Collecting video data of these discussions was a crucial set of data. Second, while not all of the activities within the classroom were a part of the intervention, this study also sought to investigate if these PSSTs used strategies taken directly from the intervention within other activities. For example, some PSSTs mentioned differentiated instruction when critiquing peer-teaching lessons. Third, collecting these video recordings allowed me to analyze all participants enrolled in the class, not just those selected and available for interviews. And fourth, as video data is retrievable, collecting it allows for repeated analyses as my framework evolves through multiple repetitions of coding. For these four reasons, video recordings were a crucial data source to collect in order to answer these research questions.

Video recordings of classroom activities were taken for every class meeting (with the exception of the first class meeting, when participants were asked for consent prior to data collection). In general, two digital camcorders, positioned at multiple angles, were set up within the classroom. During activities that involved
small group discussion, addition digital camcorders were set up to capture each
group (typically, between 3 to 5 cameras total). Approximately 90 hours of video
recordings were collected of classroom activities, split between two (2) to five (5)
digital camcorders. These activities will be discussed more in detail below. These
recordings were used to determine how the pre-service science teacher understood
and displayed culturally responsive teaching methods (this evidence and coding is
discussed in more detail below).

Another data source I collected were artifacts that the pre-service science
teachers created within this methods course. Many aspects of this intervention
required the PSST develop artifacts designed to support culturally diverse
classrooms. For example, one activity had PSSTs take an existing lesson plan they
created and modify it to incorporate differentiated instruction. This is why I
recognized the need to gather artifacts created by the PSST for analysis.

These artifacts included: unit plans; lesson plans; conceptual interviews of
middle school children; discussion forums taken during field experience, where
PSSTs had to discuss and respond to different issues within science education and
cultural diversity; self-analyses of peer teaching; a philosophy of teaching statement
written at both the beginning and the end of the semester; and a safety portfolio. I
collected and analyzed artifacts generated by all members of this methods course.
These artifacts were analyzed to determine how the PSST plans to teach science
content and how effective these strategies may be in supporting diverse classroom
environments.
Finally, audio recordings of personal interviews with PSSTs were collected to provide additional data to help answer these research questions (See Appendix A for Interview Protocol). Conceptual interviews were an important data source to collect because they probed deeper into the PSSTs’ understanding of culture. These interview questions were better suited to a one-on-one format, as opposed to a whole class discussion. Using a one-on-one format allowed the interviewer to probe deeper into the PSSTs’ responses, as opposed to responses given during discussions in the classroom. Class time was limited, whereas these interviews could spend additional time determining the background and previous experiences of selected PSSTs. In addition, interviews were able to elicit responses from the PSSTs that were more detailed than those given during class discussions. Probing questions were asked based on the responses given. Also, a one-on-one format allowed the PSSTs to feel slightly more open to responding as opposed to sharing these ideas in front of an entire class. Finally, research personnel that had no affiliation with the methods course conducted these conceptual interviews. This was done primarily to ensure that the PSSTs felt comfortable participating and provided answers openly. As the primary instructor for the class, I chose not to listen to any audio recordings until after all grades were finalized at the end of the semester. Interview subjects were made aware of this fact at the beginning of every interview.

Five PSSTs from this methods course were selected to take part in these conceptual interviews. Preferably, I would have chosen interview subjects to give as diverse a selection as possible, as well as individuals that were particularly interesting. However, these selections had to be made at the beginning of the
semester, before I could identify specific individuals that would yield the most informative data. In addition, not all individuals in the class opted to be interviewed. As such, it was difficult to choose interview subjects that would provide rich amounts of data based on very little prior knowledge. For this reason, interview subjects were chosen randomly among the group willing to participate. Conceptual interviews were conducted at both the beginning and the end of the fifteen-week methods course. The pre-interview that took place at the beginning of the semester was meant to determine the subjects’ initial experiences throughout their K-12 school culture. In addition, this pre-interview asked how the subjects view the role that culture plays within the science classroom. The post-interview that took place at the end of the semester asked how culture might play a role in the science classroom. This was intended to see whether their initial views were modified throughout the semester. In addition, the post-interview asked hypothetical situations about how to handle culturally diverse classrooms. As each interview took approximately fifteen (15) minutes to conduct, a total of two and a half (2.5) hours of audio recordings was collected.

All three data sources were essential to collect in order to conduct a proper analysis. Maxwell (2005) refers to this as the triangulation of data collection methods. Using multiple sources of data allows for a much deeper analysis. Maxwell states that doing so will give my conclusions of how PSSTs understand the role of culture within science classrooms much more credibility. He mentions that conceptual interviews allow the researcher to understand the PSST perspective of culture, while the video recordings allow inferences to be drawn about how they use
this cultural knowledge within other aspects of their science teaching. Each source of data: video recordings of classroom activities, artifacts generated within the class, and audio recordings of conceptual interviews, are important to collect. This is why pairing these data sources gave a well rounded analysis of how pre-service science teachers develop culturally relevant pedagogy. Within the next section, I discuss the setting for this study in detail.

**Setting**

This study proposed to select pre-service science teachers during their enrollment in a science methods course. This second semester science teaching methods course, SCIED 412: Secondary Science Teaching II, is required for any science teacher seeking secondary certification (grades 7 – 12) at the university where this study was conducted. Lasting fifteen weeks, the course supports PSSTs with (but not limited to) the following topic areas: unit planning, which includes discussions of big ideas and storylines; analysis of videos from science teaching; peer-teaching activities with self-reflection; assessment strategies; classroom management strategies; safety portfolios; conceptual interviews with middle or high school children; discussion of culturally relevant pedagogy; and discussion of differential instruction. While enrollment in the course varies by semester, it typically ranges from ten (10) to twenty-five (25) students. During the semester data was taken, a total of fifteen (15) students were enrolled.

This course is taught at a University located in central Pennsylvania. The Census data from the year 2010 (U.S. Census Bureau, 2010) shows a population of
approximately 42,000 within the borough, a 9.40% increase in population since the year 2000. Most of the population (71%) lies within the 18-24 age range. Approximately 82% of the population indicated their race as White, 4% as Black or African American, 10% as Asian, and 4% as Hispanic or Latino. The University itself has very similar demographical data as the borough, with 84% of undergraduates indicating their primary race as White, 4% as Black, 6% as Asian or Pacific Islander, and 4% as Hispanic (Education Portal, 2011).

**Participants and Sampling Method**

The unit of analysis for this study investigated the pre-service science teacher. Specifically, I investigated the discourse of pre-service science teachers enrolled in a second semester science methods course that participated in a near-authentic intervention program designed to support developing culturally relevant pedagogy for culturally diverse classrooms. This study was a single case study with multiple participants (15).

Participants for this study were selected from among pre-service science teachers enrolled in SCIED 412. This study included individuals who represented a wide range of backgrounds enrolled in this science teacher certification program. Participants were Juniors, Seniors, and Masters students. Occasionally, returning or continuing education students enroll in the class; however, none were enrolled during the semester this research took place. The age range for participants ranged from nineteen (19) years old to the mid-twenties. As SCIED 412 is required for all
science certification areas, enrolled students were pursuing an educational degree in all focus areas: Biology, Chemistry, Geology, and Physics.

<table>
<thead>
<tr>
<th>Name</th>
<th>Content Focus</th>
<th>Degree</th>
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</thead>
<tbody>
<tr>
<td>Allen</td>
<td>Chemistry</td>
<td>Undergraduate</td>
</tr>
<tr>
<td>Audrey</td>
<td>Geology</td>
<td>Undergraduate</td>
</tr>
<tr>
<td>Daniel</td>
<td>Physics</td>
<td>Undergraduate</td>
</tr>
<tr>
<td>Erika</td>
<td>Biology</td>
<td>Undergraduate</td>
</tr>
<tr>
<td>Frank</td>
<td>Chemistry</td>
<td>Undergraduate</td>
</tr>
<tr>
<td>Karen</td>
<td>Biology</td>
<td>Undergraduate</td>
</tr>
<tr>
<td>Jeffrey</td>
<td>Chemistry</td>
<td>Masters</td>
</tr>
<tr>
<td>Paul</td>
<td>Geology</td>
<td>Undergraduate</td>
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<tr>
<td>Phillip</td>
<td>Biology</td>
<td>Undergraduate</td>
</tr>
<tr>
<td>Rebecca</td>
<td>Chemistry</td>
<td>Masters</td>
</tr>
<tr>
<td>Robert</td>
<td>Chemistry</td>
<td>Masters</td>
</tr>
<tr>
<td>Samantha</td>
<td>Biology</td>
<td>Undergraduate</td>
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<tr>
<td>Sharon</td>
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<td>Undergraduate</td>
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<tr>
<td>Travis</td>
<td>Biology</td>
<td>Undergraduate</td>
</tr>
<tr>
<td>Virginia</td>
<td>Biology</td>
<td>Undergraduate</td>
</tr>
</tbody>
</table>

Table 3.1 List of participants by pseudonym, content area, and degree sought

Interpretive Biography
I was born in 1979 to a White, middle-class family of four. Predominantly, my K-12 experiences were situated within suburban, middle-class school districts whose student population lacked cultural diversity. With close to six hundred students in my graduating high school class, only a handful of these students were African-American. Additionally, my high school was well funded: many clubs and extra-curricular activities were available for students, and computers were provided to all of the science classrooms. Reflecting on these experiences, I now realize how sheltered I was from experiencing the issues of lack of opportunity and missed the opportunity to benefit from diversity in my own K-12 education.

I became interested in research on culturally relevant pedagogy due to my own shortcomings to understand how cultural diversity can affect science instruction. I wanted to improve upon my own practices while additionally help struggling science educators that feel they are ill-equipped to handle culturally diverse classrooms. This posed a difficult task, as I constantly doubted my ability to understand the challenges stemming from cultural diversity due to my sheltered experiences. I repeatedly questioned and reflected upon my own practices as I recognized how little authentic experience I had with cultural diversity.

My self-doubts hindered my efforts during most of this study. However, other educational research on CRP was helpful when developing this intervention. I would continually familiarize myself with current educational research on CRP to identify ways this intervention could be improved. I continually questioned my own practices, adapting when necessary to better present the framework for CRP to my students. My self-doubts were used as a strength to constantly view my practices as
“good, but could be better.” I feel strongly about my work throughout this study, as my practices were based on current CRP research and refined when I identified specific weaknesses supporting CRP within classroom activities.

**Classroom Activities**

In order to support developing culturally relevant pedagogy, I proposed that pre-service science teachers should be able to:

- Acknowledge culture as a force that influences learning,
- Recognize that culturally relevant pedagogy requires adjusting core teaching methods,
- Expand their notions of what “good science teaching” looks like beyond past experiences,
- Understand how to address the needs of the students and how instruction may be adapted to suit these needs.

These propositions are based upon Ladson-Billings’ (2001) framework for culturally relevant teachers. In addition, as PSSTs tend to primarily develop pedagogy based on informal knowledge gained through prior learning experiences (Hedges, 2012), I also proposed that PSSTs needed to expand their notions of science education. This involved challenging PSSTs to expand beyond their own experiences learning science and critically examine how others learn science.

During this methods coursework, pre-service science teachers learn about cultural variation. This involved changing teacher attitudes and beliefs towards
culture in the science classroom, as outlined above. This was accomplished through support in: developing teaching strategies based on research on assessment, reflection, and adaptation; incorporating differentiated instruction methods into PSST generated lesson plans; using assessment strategies to modify instruction to better suit the needs of the students; and using examples of culturally relevant pedagogy to critically think about its impact on science education. As discussed in the theoretical framework, these strategies are critical tools that pre-service science teachers require in order to teach science to diverse classrooms.

**Supporting Diverse Learners within the Classroom**

Developing teaching strategies to support diverse learners provides pre-service science teachers a gateway into more sophisticated CRP strategies. Strategies such as assessment, reflection, and adaptation are effective at supporting the needs of diverse learners. For example, Flores (2007) investigated the experiences of four new teachers at urban school districts and found they were successful when incorporating “different means of demonstrating understanding.” Adadan (2009) found that high school chemistry students were best supported when considering the individual needs of each student. This involved using multiple modes of representation, technology, formative assessment, and journal writings.

Within this intervention, PSSTs were challenged to use assessment, reflection, and adaptation to modify their pedagogy. Specifically, these strategies were: using multiple models for the structure of lessons; integrating multi-representational tools such as visual and audio aides into instruction; integrating
technology into lessons; and presenting content objectives in multiple ways. These strategies were presented to the PSSTs, and class discussions involved their own views, the benefits and roadblocks of considering these views within their future science classrooms, and ways in which they could modify their lesson plans to incorporate these strategies into their own practices. Throughout the intervention, PSSTs were asked to modify an existing lesson plan to incorporate these teaching strategies. This was one of the many artifacts collected for data analysis.

These were not the only instances where the concept of these teaching strategies were brought up. For example, PSSTs would discuss how to integrate these strategies during peer teaching activities. Many other activities within the class also found evidence of PSSTs expressing their views on assessment, reflection, and adaptation. I describe the previous examples because they were specifically designed for the intervention. However, all instances of PSSTs expressing their views on these strategies were coded, regardless of the context in which it took place.

**Differentiated Instruction**

In order to support pre-service science teachers in thinking about differentiated instruction, many different activities were developed for this intervention. Journal articles were provided that helped to familiarize PSSTs with the concept of differentiated instruction (George, 2005; Holloway, 2000; Huebner, 2010; Sternberg & Zhang, 2005). After readings these journal articles, PSSTs discussed how their instructional techniques could be modified or changed based on
the demographics of a hypothetical classroom (e.g. academically diverse classrooms, co-ed versus all female students, rural classroom versus urban classrooms, etc).

In addition, the peer teaching activity was used to provide experience in using differentiated instruction within science lessons. As this methods course was required for certification in any of the secondary science content area, this methods course had a mix of students with different subject content areas. This provided an excellent opportunity for PSSTs to become accustomed to differentiated instruction, as they had to provide meaningful experiences for all students, regardless of prior content knowledge.

**Assessment Strategies**

Pre-service science teachers should receive support in different types of assessment strategies and how to best use those strategies. One assessment activity that PSSTs had to perform was a conceptual interview. PSSTs were required to conduct a conceptual interview during their field experience with three children, preferably a low-performing, a medium-performing, and a high-performing academic child. PSSTs had to then write an essay detailing the results of the conceptual interview. Another assessment activity PSSTs had to conduct was a well-rounded assessment strategy that was used within their peer teaching activity. Throughout the semester, different assessment strategies were discussed and analyzed. After each student’s peer teaching activity, the student was required to provide a reflection on the assessment strategies they used during their peer teaching activity and how effective those strategies were.
**Examples of Culturally Relevant Pedagogy**

To provide PSSTs with examples of culturally relevant pedagogy, PSSTs explored websites and resources pertaining to culturally relevant pedagogy. Some video examples of classroom teaching within multiple cultural contexts were shown, and PSSTs were asked to watch, reflect, and discuss as a class. PSSTs were involved in discussions of intuitions and misconceptions that children may have within their content area. Some intuitions and misconceptions were specific to certain cultural contexts; for example, how the topic of evolution may be viewed by Southern Baptists, or how the idea of Climate Change may be viewed differently within various socio-economic groupings. In another activity, PSSTs researched different culturally diverse school districts to gather any information they felt would be helpful when developing unit plans for those children.
# Timeline

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<thead>
<tr>
<th>Week</th>
<th>Tuesday</th>
<th>Thursday</th>
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<tr>
<td>Week 1</td>
<td>08/28: Overview of CRP research project, handed out and collected consent forms (No Data)</td>
<td>08/30: Critique of classroom video, discussion of inquiry, overview of unit plan assignment</td>
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<tr>
<td>Week 2</td>
<td>09/04: Instructor taught lesson, PSSTs critique instructor lesson, assessment activity, introduction to CRP</td>
<td>09/06: Peer Teaching Karen &amp; Erika, critique of peer teaching*, management scenarios and root causes for negative behavior, work on unit planning</td>
</tr>
<tr>
<td>Week 3</td>
<td>09/11: Peer Teaching Paul, critique of peer teaching*, overview of peer teaching analysis assignment, differentiated instruction activity, modified pedagogy to support diverse learners assignment (1st time)</td>
<td>09/13: Peer Teaching Robert, critique of peer teaching*, modified pedagogy assignment, discussion of modified pedagogy to support diverse learners and its connection to CRP</td>
</tr>
<tr>
<td>Week 4</td>
<td>09/18: Peer Teaching Sharon, critique of peer teaching*, discussion of big idea and phenomenon, work on unit planning</td>
<td>09/20: Peer Teaching Daniel, critique of peer teaching*, discussion of assessment and CRP</td>
</tr>
<tr>
<td>Week 5</td>
<td>09/25: Peer Teaching Rebecca*, critique of peer teaching*, overview of discussion blogs and conceptual interview assignments, introduction to field experience</td>
<td>09/27: Peer Teaching Frank, critique of peer teaching*, discussion of field experience, classroom management scenarios and CRP</td>
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<tr>
<td>Week 7-11</td>
<td><strong>Field Experience</strong> - Discussion Blogs</td>
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<td></td>
<td>Week 1 - What was something that surprised you when you started your field experience?</td>
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<td></td>
<td>Week 2 - What are some classroom management issues you've encountered and how did you (or your mentor) deal with it?</td>
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<td>Week 3 - How do you (or your mentor teacher) attempt to incorporate students' home lives with their school</td>
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<tr>
<td>Week 12</td>
<td>11/13: Reflection on field experience and discussion blogs</td>
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<tr>
<td>Week 13</td>
<td>11/27: Peer Teaching Travis &amp; Philip, critique of peer teaching*, discussion of connecting to student interests, work on unit planning</td>
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<tr>
<td>Week 14</td>
<td>12/04: Peer Teaching Jeffrey, critique of peer teaching*, CRP activity</td>
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<tr>
<td>Week 15</td>
<td>12/11: Peer Teaching Allen, critique of peer teaching*, wrap-up discussion of CRP</td>
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Note: Critique of peer teaching discussions, while not explicitly stated, included discussing foundations of CRP in relation to the previously taught peer teaching lesson. As stated within "Chapter 3: Methodology," these discussions were critical components of the intervention. Ongoing themes within these discussions included, but were not limited to: language use within science instruction, using assessment to guide instruction, using DI within instruction, and how culture understandings influence science instruction.
Evidence for the development of CRP

To determine whether these classroom activities had a significant effect on pre-service science teachers’ views on cultural relevant pedagogy, care was taken to consider how to best define and measure change in these teachers’ views over time. This involved a detailed analysis of evidence gathered that indicated a change, or lack thereof, in how these PSSTs view and design their pedagogy. This evidence was found within the data gathered from personal interviews, classroom observations, and the collection of artifacts throughout the course. However, in order to claim specific sections of data as evidence for PSSTs views on CRP, a proper coding framework needed to be developed. To develop a proper coding framework, I had to first identify how other researchers identify evidence for the development of CRP. Specifically, I used a framework that Ladson-Billings (2001) developed that classified specific criteria teachers must possess in order to thrive within culturally diverse settings.

Evidence of Culturally Relevant Pedagogy

Ladson-Billings (2001) outlines the criteria that a culturally responsive teacher must possess in order to thrive within culturally diverse settings. The criteria she proposed are:

| Indicators of Academic Achievement, the teacher... | Cultural Competence occurs in classrooms where the teacher... | Indicators of Sociopolitical Consciousness, the teacher... |
1.1 - Presumes that all students are capable of being educated
1.2 - Clearly delineates what achievement means in the context of the classroom
1.3 - Knows the content, the learner, and how to teach content to the learner
1.4 - Supports a critical consciousness toward the curriculum
1.5 - Encourages academic achievement as a complex conception not amenable to a single, static measurement

2.1 – Understands Culture and its role in education
2.2 – Takes responsibility for learning about students’ culture and community
2.3 – Uses student culture as a basis for learning
2.4 – Promotes a flexible use of students’ local and global culture

3.1 – Knows the larger sociopolitical context of the school-community-nation-world
3.2 – Has an investment in the public good
3.3 – Plans and implements academic experiences that connect students to the larger social context
3.4 – Believes that students’ success has consequences for his or her quality of life

These criteria can be aligned with NCATE’s Standard 4a: Design, Implementation, and Evaluation of Curriculum and Experiences (NCATE, 2008).

These standards state that teacher certification programs require that Universities:

“Promote candidates’ development of knowledge, skills, and professional dispositions related to diversity; Based on well developed knowledge bases for, and conceptualizations of, diversity and inclusion so that candidates can apply them effectively in schools; Learn to contextualize teaching and draw effectively on representations from the students’ own experiences and culture; Challenge students toward cognitive complexity and engage all students, including ELL and students with exceptionalities, through instructional conversation; Candidates and faculty regularly review candidate assessment data on candidates’ ability to work with all students and develop a plan for improving their practice and the institution’s program”
These two sets of standards outline the fundamental characteristics that teachers must possess to teach within culturally diverse settings. Given the overlap between the standards from Ladson-Billings and NCATE, it was redundant to require using both sets of standards as evidence of success. Therefore, the standards that Ladson-Billings outlined above were used to evaluate the effectiveness of training PSSTs with CRP. A coding framework was developed to highlight observable instances of PSSTs engaging in CRP practices, and these observable instances were linked to the framework that Ladson-Billings provides.

Data Analysis

As previously stated, data for this study was collected from videos of classroom observations, audio recordings of personal interviews, and artifacts created by PSSTs during the class. Participants for this case were pre-service science teachers currently enrolled in a science education methods course that engaged in a near-authentic intervention designed to help support the development of culturally relevant pedagogy. The units of analyses for this case were the discourse meaning units of these PSSTs while participating in this intervention, which included video, audio, and written form.

Data collected from videos of classroom observations and audio recordings of personal interviews were analyzed using the Studiocode software. Studiocode is a “video analysis tool used within the healthcare, education, research and corporate
sectors to improve, measure, and analyze performance” (Studiocode Business Group, 2006).

A coding framework was developed through analysis of the data, which allowed the researcher to identify common themes. Codes are a type of categorizing strategy used during data analysis. Codes are useful within qualitative studies because they can organize the data within certain themes or categories in order to better help the researcher compare different instances of similar data (Maxwell, 2005). I used an open coding method when analyzing this data (Strauss, 1987). During the coding process, themes emerged that were not inherently clear at the beginning. Open coding allowed me to continually refine my coding framework during the analysis process. In the following sections, I detail each version of my coding framework I used for my analysis. Each version built upon its predecessor, either by the creation of codes within codes or by removing dead-end codes that were not useful for this analysis. In total, there were three versions of the coding framework I used while analyzing this data. While I do provide a general description for each version, I gave a more detailed description for the third and final version, as it became the crux for my analysis.

**Coding Framework Version 1.0**

The first version of my coding framework used only one code: “Interesting.” While watching videos of classroom activities, I would code any sections of data where an event occurred that was in someway related to the development of CRP. In some events, this included PSSTs making statements about their views on the
influence a student’s cultural understandings have within science classrooms. Other events included PSSTs making statements on their pedagogical decision making processes, and whether or not those processes included considering cultural understandings. Every code was marked with a note that explained why it was interesting and how it related to the development of CRP. While using this code did not provide the in-depth analysis needed for this study, I found it useful to identify specific trends that would later become a new coding framework.

**Coding Framework Version 2.0**

The “Interesting” code lead to the development of four overall themes to statements made by PSSTs. Each of these themes was given a specific code to use during the analysis: (1) Lesson Planning, when the PSST made an assumption (e.g. “I think students will be engaged with this lesson because…”,”I think I would handle culturally diversity in my classroom by…”); (2) Lesson Enactment, when the PSST was teaching a content-specific science lesson (e.g. assessment strategies used within the lesson, pedagogical decisions made by the PSST); (3) Lesson Reflection/Critique, when the PSST reflected on their actions or critiqued a peer’s actions (e.g. “I had trouble at the start of my lesson because…”,”One thing you may want to consider to try in your lesson is…”); or (4) Justifications, when the PSST gave a justification for their statement or action (e.g. “I chose to teach this lesson because…”; “I think culture is important to consider because…”). The Justifications code was a special case, as this was not a mutually exclusive code. “Justifications” was coded in tandem with the other codes. For example, the code “Lesson
Reflection/Critique” may be paired with a “Justification” code because a PSST mentioned that he or she did this lesson in high school and enjoyed it. Another example, the code “Lesson Planning” may be paired with a Justification code because a PSST uses his or her own personal experience with being a camp counselor as a basis for how to teach a diverse classroom of children.

**Coding Framework Version 2.1**

Within this version of the coding framework, I worked towards breaking down each of those larger codes into smaller sub-codes.

<table>
<thead>
<tr>
<th>Cultural</th>
<th>Pedagogical</th>
<th>Content</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lesson Planning</td>
<td>Assumptions of Student Cultural Knowledge</td>
<td>Assumptions of Effective Pedagogical Strategies</td>
</tr>
<tr>
<td>Lesson Enactment</td>
<td>Pedagogical Decision Making</td>
<td></td>
</tr>
<tr>
<td>Lesson Reflection/Critique</td>
<td>Recognized Student Cultural Knowledge</td>
<td>Evaluation of Pedagogical Strategies</td>
</tr>
</tbody>
</table>

*Figure 3.1 Coding Framework Version 2.1*

Looking closely at “Lesson Planning” and “Lesson Reflection/Critique”, I found that the PSST made statements that could be classified into three categories: (1) Cultural, where the PSST made a statement about their views on culture; (2) Pedagogical, where the PSST made a statement about their pedagogical decision making; and (3) Content, where the PSST made a statement about their specific
content area. Using this, I was able to break down the larger codes into smaller sub-codes. “Lesson Planning” was divided into three subcodes: “Assumptions of Child Cultural Knowledge,” “Assumptions of Effective Pedagogical Strategies,” and “Assumptions of Child Content Knowledge.” In a similar fashion, “Lesson Reflection/Critique” was also divided into three subcodes: “Recognized Child Cultural Knowledge,” “Evaluation of Pedagogical Strategies,” and “Assessed Child Content Knowledge.”

“Lesson Enactment” was intended to code the pre-service science teachers’ peer-teaching lessons. Two sub-codes were developed for this: (1) “Pedagogical Decision Making,” which marked the types of teaching strategies PSSTs use within their lesson; and (2) “Assessment Strategies,” which marks where PSSTs use assessment techniques.

Finally, the “Justifications” code was looked at, but I did not find it needed to be broken down into sub-codes. This code was specific enough to warrant its use; plus, it was used in tandem with the other sub-codes that were already broken down.

All codes included a note to indicate what kind of activity the PSST was involved in when they made a statement (e.g. “Students critique a peer teaching lesson,” “Students participate in group discussion of,” etc). These notes also included a brief paraphrased description of what the PSST said. Each code was color coded, which made it easier for analysis. Finally, all of the coded data was inputted into Evernote, which is a computer application that organizes notebooks. There were separate notebooks created to include each individual PSST (15 total), each
individual date (16 total), and one final overall timeline of all data. Each coded instance included a title that identified the PSST’s pseudonym, the date, and the code. The notes for each code were copied and pasted under the title.

Artifacts from class were also analyzed to determine whether the pre-service science teacher integrated culturally relevant strategies into their pedagogy. It was important to see whether a lesson plans took into account a child’s cultural values, which can lead to intuitions and misconceptions about the material. These artifacts will be helpful in providing supporting evidence gathered from the video and audio recordings taken of the classroom activities and personal interviews.

**Coding Framework Version 3.0**

The final coding framework is included below. Two main themes, “Strategies To Support Diverse Learners” and “Cultural Understandings” emerged as the primary codes. Sub-codes were split into prior to and after field experience, as the data suggested that the field experience became a catalyst for change in the PSSTs’ views. These codes were grouped into specific themes and used for the final analysis of this data.
<table>
<thead>
<tr>
<th>Codes: (Diverse Learners)</th>
<th>Subcodes</th>
<th>Description</th>
<th>Transcription Example</th>
<th>Link to Ladson-Billings’ Framework</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Prior to Field Experience:</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>K-12 Experiences</td>
<td>PSST draws upon his/her own K-12 experiences when developing science pedagogy</td>
<td></td>
<td>Rebecca (09-06): “Because I’ve had teachers do that so the students can still look back, but it’s after class so they still have to take notes.”</td>
<td></td>
</tr>
<tr>
<td>Effective Pedagogy</td>
<td>PSST suggests criteria necessary for effective science pedagogy</td>
<td></td>
<td>Jeffrey (09-18): “Maybe try and get more discussion amongst the students so it’s on them.”</td>
<td></td>
</tr>
<tr>
<td>Views on Strategies</td>
<td>PSST critiques modified pedagogy to support diverse learners</td>
<td></td>
<td>Robert (09-13): “It lets students take real control of what they learned and how they learn it.”</td>
<td></td>
</tr>
<tr>
<td><strong>After Field Experience Positive View - PSST makes a statement of how modified pedagogy to support diverse learners can help/has helped science instruction</strong></td>
<td>Reflection</td>
<td>PSST values reflection as a tool to use within science pedagogy</td>
<td>Rebecca (11-02): “So when I do have an unsuccessful lesson I definitely take some time to figure out where it went wrong... when a lesson does go bad I reflect on the moments where I lost confidence or at what point the students were lost.”</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Adaptation</td>
<td>PSST values adaptation as a tool to use within science pedagogy</td>
<td>Karen (10-31): “Adaptation is really the key to fixing an unsuccessful lesson... I think that as long as you accept that a method is not working, and move on, you can fix the lesson.”</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Agent of Change</td>
<td>PSST values the need to focus on themselves as an agent of change within the science classroom</td>
<td>Travis (11-01): “However, it is my responsibility to teach them the lessons I create and make sure they understand the material.”</td>
<td></td>
</tr>
<tr>
<td><strong>After Field Experience Negative View - PSST makes a statement on modified pedagogy to support diverse learners won’t help/hasn’t helped science instruction.</strong></td>
<td>Unable to Modify</td>
<td>PSST unable to modify pedagogy based on these strategies / believe that science content can only be taught one way</td>
<td>Jeffrey (11-06): “I have tried to use (strategies to modify pedagogy) in the classes where I can, but again these lessons I have been teaching have been very math based or just fact based.”</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Repitition</td>
<td>PSST uses repetition as a form of modified pedagogy</td>
<td>Audrey (11-01): “… where I first model the skill and do several examples, and then I have them tell me how to answer a couple examples, and I prompt them with the instructions, and then I have them do a couple on their own.”</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Resistance</td>
<td>PSST encounters student resistance when attempting to modify pedagogy based on these strategies</td>
<td>Erika (11-03): “We have showed diagrams, taught the material twice, reviewed the material four times, we have shown videos, interactive moving diagrams, drew examples on the chalkboard... there are still students who are struggling.”</td>
<td></td>
</tr>
</tbody>
</table>

1.4 - Supports a critical consciousness toward the curriculum
PSSTs need to be mindful of the ways they teach science content. The strategies used within MI help PSSTs reflect upon their practices and adapt instruction to better suit the needs of their students.

1.5 - Encourages academic achievement as a complex conception not amenable to a single, static measurement
MI strategies require PSSTs to present science content in multiple different ways in order to support all learners. PSSTs need to recognize that academic achievement is not limited to exam results.

Figure 3.2 Strategies to Support Diverse Learners Coding Framework
### Codes: (Culture)

<table>
<thead>
<tr>
<th>Description</th>
<th>Transcription Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>PSST considers the impact a student's cultural understandings has upon science instruction</td>
<td><em>Erika</em> (09-17): “But if you're in inner-city where there's no green anywhere, it's like you don't have enough money to go out, experience any of that, or you don't see any wildlife, then you're already a step below the people who see it.”</td>
</tr>
<tr>
<td>PSST analyzes the language used during science instruction</td>
<td><em>Jeffrey</em> (09-27): “I call myself a nerd all the time. But I know I've read that, don't refer to people who are scientists or people engaged in science as nerds. Because, although we say it jokingly, it might impact (the students’) view of scientists.”</td>
</tr>
<tr>
<td>PSST values the need to consider the home lives of students when designing pedagogy</td>
<td><em>Rebecca</em> (10-20): “My mentor teacher told me about the many struggles the students have at home… I learned that when a student doesn’t do his or her homework or does poorly on the exam, laziness or apathy shouldn’t be the first assumptions we should be making as teachers.”</td>
</tr>
<tr>
<td>PSST values the need to engage disinterested students</td>
<td><em>Sharon</em> (11-01): “Some of the problems that you talked about -- students not paying attention or not trying -- I have experienced in my classroom as well. However I did find that sometimes, those students just need a little more encouragement and one-on-one.”</td>
</tr>
<tr>
<td>PSST views culture in terms of statistical data / Ignores the surrounding community</td>
<td><em>Frank</em> (12-04): “The population of the town is approximately 61,000. The student to teacher ratio is about fifteen-to-one. About the community, it's over 60% republican. The state has a republican governor, though both of their senators and their house representative are democrat.”</td>
</tr>
<tr>
<td>PSST discouraged by the negative behavioral aspects of students / No attempt to determine the root cause for these behaviors</td>
<td><em>Erika</em> (11-13): “I don’t know, it’s just like, they just didn’t care, and some of them were honestly kind of lazy.”</td>
</tr>
</tbody>
</table>

#### Prior to Field Experience:

- **Cultural Influence**: PSST considers the impact a student’s cultural understandings has upon science instruction.

- **Language**: PSST analyzes the language used during science instruction.

#### After Field Experience

- **Positive View - Home Lives of Students**: PSST makes a statement of how they would consider/have considered a student’s culture in science instruction.

- **Engagement**: PSST values the need to engage disinterested students.

- **Naive View of Culture**: PSST views culture in terms of statistical data / Ignores the surrounding community.

- **Negative Behavioral Aspects**: PSST discouraged by the negative behavioral aspects of students / No attempt to determine the root cause for these behaviors.

#### Figure 3.3 Cultural Understandings Coding Framework

1. **1.1 - Presumes that all students are capable of being educated**
   - PSSTs need to accept the cultural backgrounds of the students they teach and assume all of their students have the capacity to learn and do science.

2. **2.1 – Understands Culture and its role in education**
   - PSSTs need to acknowledge that culture is a significant influence when learning and doing science.

3. **2.2 – Takes responsibility for learning about students’ culture and community**
   - PSSTs need to be socially conscious about the home lives and interests of their students in order to build a rapport.

4. **2.3 – Uses student culture as a basis for learning**
   - PSSTs need to adapt their instruction to include cultural understandings within their pedagogy.

5. **3.3 – Plans and implements academic experiences that connect students to the larger social context**
   - PSSTs need to consider the home lives and interests of the students they teach to emphasize the importance of learning and doing science outside the context of the classroom.
Conclusion

The research questions for this study were:

1) How do pre-service science teachers view and design pedagogy while participating in an intervention designed to support the development of culturally relevant pedagogy?

2) How do pre-service science teachers view the importance of culturally relevant pedagogy for supporting student learning? How do their practices in the field change these initial views?

These questions were investigated through a case study on a pre-service science teaching methods course. Subjects for the case study included students enrolled in the science teaching methods course. Data was collected from classroom observations, personal interviews, and artifacts collected throughout the semester. The data was analyzed using Studiocode software to determine a pre-service science teacher's ability to develop culturally relevant pedagogy. In the next chapter, results from this study are presented and analyzed.
Chapter 4 – Analysis and Findings

Using the coding framework outlined in Chapter 3, I analyzed all of the data obtained throughout this science methods class. This included over ninety (90) hours of video of participation in classroom activities and peer teaching lessons; audio recordings of conceptual interviews conducted with a selected portion of the class; blog entries with peer responses written during field experience; and general artifacts created by the class (i.e. unit plans, philosophy of science position statements, reflections on peer teaching exercises, and conceptual interview reports of field experience classes). While this analysis provided multiple insights into pre-service science teacher education programs, my research questions focused on how two specific aspects ground the impact on PSSTs’ development of culturally relevant pedagogy. The first research question is: How do pre-service science teachers view and design pedagogy while participating in an intervention designed to support the development of culturally relevant pedagogy? The second research question is: How do pre-service science teachers view the importance of culturally relevant pedagogy for supporting student learning? How do their practices in the field change these initial views? Each analysis includes an overall claim, a detailed analysis of the data to support the claim, and factors that influenced these results.

A central theme emerged within both analyses that identified PSSTs pedagogical decision-making processes. The diagram, entitled “PSSTs’ CRP Decision Making Processes” (Figure 4.1), illustrates specific trends that emerged which influenced how these PSSTs designed culturally relevant pedagogy. While these trends are discussed in more detail below, the PSSTs’ CRP Decision Making
Processes diagram has been provided as an overview that will be referenced multiple times within the analysis. In addition, sections within the PSSTs’ CRP Decision Making Processes diagram are expanded upon in further detail below.

Looking across these two groups of PSSTs, certain trends emerge of how they view and modify their pedagogy (see Figure 4.1). At the start, the PSSTs’ initial views on culturally relevant pedagogy have a strong influence on their attitudes and pedagogy before interacting with students. When the PSST is successful in using CRP, he or she will attribute that success to either the pedagogy or to the students. In the case of the pedagogy, the PSST integrated strategies learned from developing CRP from the intervention and saw how it can be an agent of change for diverse students. In the case of the students, the PSST believes that the students were responsible for success, regardless of how the science content was taught. However, when the PSST is unsuccessful in using CRP, he or she will again attribute that failure to either the pedagogy or to the students. If the pedagogy was to blame, the PSST will reflect on their practices, adapt their instruction, and attempt to teach the content again. This process repeated multiple times until either the PSST was eventually successful, or the PSST reached a breaking point and placed the blame for failure on the student. When this happened, the PSST will move on with instruction without further attempts to support struggling students.
PSSTs’ CRP Decision Making Processes
(Figure 4.1)

Initial Views on Culturally Relevant Pedagogy

(A)

PSST attempts to teach content using CRP

Success

Was success due to pedagogy, students, or both?

Pedagogy

CRP is developed successfully for all students

Students

Students thrive regardless of pedagogy used

Challenges

Was failure because of pedagogy or because of students?

Pedagogy

(A) Reflect on practices, Adapt instruction

Students

PSST places blame on student(s) for failure. Does not adjust pedagogy
Analysis: How do pre-service science teachers view and design pedagogy while participating in an intervention designed to support the development of culturally relevant pedagogy?

Overall Claim

My analysis of the data found that pre-service science teachers initially value the importance of designing pedagogy to support diverse learners due to their belief that it can support achievement in science for all students. However, after participating in a field experience, these pre-service science teachers diverge into two groups: those that observed an increase in achievement for all students after designing their pedagogy to support diverse learners, and those that designed their pedagogy to support diverse learners but did not observe an increase in achievement for all students. The patterns these two groups exhibit in terms of how they attribute their success and challenges, and their choices of pedagogical responses mark them as distinct groups.

I expand on this claim in much more detail below; both before and after the PSSTs participated in their field experience. The field experience for PSSTs was found to be a catalyst for change in their views on strategies discussed during the intervention. Please note that transcribed quotes have been slightly edited to omit utterances of filler words, repeated speech, trailing off, etc. This was done in order to provide the reader with a cleaner, more focused quote while still keeping to the original intent.
Prior to field experience

While participating in an intervention designed to support PSSTs in developing culturally relevant pedagogy, PSSTs begin to value the importance of designing their pedagogy to support diverse learners due to their belief that it can support achievement in science for all students. Specifically, these values are: (1) a recognition of the diverse ways students learn science; and (2) a belief that science content can be taught in multiple ways to support diverse learners.

Prior to the intervention, PSSTs have a limited view of what good science teaching looks like. Results from early in the semester found that pre-service science teachers tend to primarily draw upon their own experiences learning science when designing pedagogy. Supporting evidence for this trend was taken solely from video data of classroom activities. Multiple instances found PSSTs making statements that supported this trend. While instances were found throughout the entire semester, these statements were more prevalent during the first few weeks of the methods course.

The justification code, which marks video data of classroom activities whenever a PSST gives a justification for a statement they made, found multiple instances where a PSST would draw upon their past experiences when making decisions within science teaching. The majority of these justifications PSSTs give are based on their own personal experiences (i.e. from high school science lessons, from college lab experiences, from camps and other informal settings). I found that PSSTs would give examples from their prior experiences learning science during many
different classroom activities, such as class discussions and peer teaching critiques. These activities did not specifically ask PSSTs to recount their own experiences; PSSTs would provide examples of their own accord. For instance, Erika mentions her own high school experiences during a class discussion on designing science pedagogy:

_Erika_ (09-04): “I really like group work, but I feel that sometimes... especially if you have a morning class and some people are tired and don’t care... sometimes in groups it turns into two or three people discussing and the other person is sitting there (doing nothing). Which I’ve done in high school sometimes, I’ll let them handle it, and then wonder what’s happening, and then just lose track (of the lesson)...”

_Erika_ is not the only PSST influenced by her prior experiences in learning science. Other PSSTs in the class also used their past experiences to guide their decision making. _Jeffrey_ provides an idea about how to encourage students to respond in class and not be worried about being wrong, an idea that was used by a former teacher of his. _Rebecca_ also uses examples from her former teachers, as she suggests a way science teachers can balance having students take notes while also having them pay attention to a PowerPoint presentation:

_Jeffrey_ (09-04): “Something that a teacher I know does is, she does something called ‘My Favorite No.’ She has a warm-up problem for her class. And then she collects it, she goes through them, sorts them, and finds the one that she likes the best that’s not correct. For specific reasons, that this is a good talking point, good teaching point. A lot of people are making this mistake. They did some things that were really good, but they also did some things that didn’t get them to the right
answer. And so she takes the name off it, rewrites it herself, and then projects it in front of the class. She asks ‘Okay, this is my favorite no for the day. Who can tell me something really good about it?’ Or she asks ‘Where can we improve?’ She said students actually came up to her and asked, ‘Why don’t I ever get to be your favorite no?’ She would tell them ‘Well, because you’re not wrong!’ It’s interesting because students actually want to be picked. They don’t want to be wrong, but maybe feel that it’s okay to be wrong.”

Rebecca (09-06): “A good marriage between the two is students don’t have anything in front of them, and then you give the PowerPoint presentation. And then you can put up the PowerPoint after class (for students to take notes). Because I’ve had teachers do that so the students can still look back, but it’s after class so they still have to take notes.”

Erika, Jeffrey, and Rebecca are all influenced by their own past experiences learning science when making pedagogical decisions. Furthermore, as they mention these past experiences within different aspects of the class (i.e. suggestions about group work, encouraging student responses, giving a PowerPoint presentation), it shows that these past experiences have a strong influence on PSSTs’ pedagogical decision-making processes. This influence affects all pedagogical design by the PSSTs, which also includes CRP; therefore, it has been added to the PSSTs’ CRP Decision Making Processes diagram as a contributing factor for the PSSTs’ initial views on CRP.

This is an important claim to consider when attempting to support PSSTs in developing culturally relevant pedagogy. While drawing on past experiences in
pedagogical design is not necessarily detrimental, this pattern of design becomes a
barrier to developing culturally relevant pedagogy as it can lead to designing
pedagogy better suited to the optimal learning style of the PSST rather than that of
the student. Diverse science classrooms require instructional designs that are more
diverse from the science teacher’s personal experience. PSSTs set their own
experience as a first priority in science teaching. While PSSTs may value the ways in
which they learned science content, they should also acknowledge science content
should be taught in diverse ways to support all science learners. As such, the
intervention began by expanding PSSTs’ notions of pedagogical design beyond their
own prior experiences. In order to do this, the intervention introduced strategies to
modify pedagogy to support diverse learners.

Modifying pedagogy to support diverse learners uses strategies that help
support culturally diverse science classrooms. For PSSTs to become proficient at
developing CRP, they must first acknowledge that content should be presented in
multiple ways to support the needs of all students (Adadan, Irving, & Trundle, 2009;
Flores, 2007; Sulaiman, Abdurahman, & Rahim, 2010). Just as students are diverse
with their cultural understandings, so too should pedagogy be diversified in order to
provide students with multiple opportunities to understand science content. This is
not to say that there exists an optimal way to teach science content to all learners,
far from it; rather, for PSSTs to be successful at developing CRP, they must integrate
multiple pedagogical methods into their practices to support each and every learner
within the science classroom. Analysis of my data from early in the semester shows
that PSSTs have an initial, albeit novice, acknowledgement that science content can
be presented in different ways. One example is when a pre-service science teacher, Virginia, comments on a peer teaching lesson taught by another PSST:

Virginia (09-11): "And I thought that your PowerPoint was really helpful, to show pictures of your examples and to really bring your points home... I thought it made it much more clear, being able to hear you talk about it and see the pictures."

Here, Virginia recognizes that combining a visual representation with a PowerPoint presentation was helpful for her to understand the science content better. This recognition is a novice understanding of pedagogy to support diverse learners, as Virginia’s statement mentions only a minor detail as opposed to core instructional methods; that is, making a statement that considers the instructional strategies used throughout the entire lesson. When discussing modified pedagogy to support diverse learners, an expert notion would modify whole lessons to integrate multiple teaching strategies for teaching specific science content. Virginia’s statement is identified as novice because she mentions only pieces of a lesson. In addition, Virginia’s statement is identified as novice because she does not make any significant modification to the core teaching method (i.e. PowerPoint presentation with only text versus PowerPoint presentation with text and pictures).

While Virginia’s recognition is only a basic understanding of modifying pedagogy to support diverse learners, it does provide a starting point for the intervention to expand on these recognitions. PSSTs initial notions about culturally relevant pedagogy need to be expanded past solely their own experiences learning science. Strategies inherent within modified pedagogy to support diverse learners
can help do this, as it provides a gateway into more sophisticated CRP strategies by challenging PSSTs to think beyond how they learn science into how each student within a diverse science classroom learn science. By using diversity in student learning and diversity in student understanding, the intervention can help PSSTs understand other forms of diversity, such as cultural diversity. In the above example, *Virginia* does not identify her statement as an example of strategies to support diverse learners. However, *Virginia* does recognize the method as an example of good science teaching. This recognition is a part of *Virginia*’s initial views on good science teaching.

Given this, the intervention began by building upon these initial views to achieve a new conception of pedagogy. As stated previously, PSSTs’ past experiences learning science are a huge influence on how PSSTs view good science teaching. The intervention does not seek to change these views or establish new paradigms; rather, the intervention identifies PSSTs’ initial knowledge of science teaching and uses that to build upon and develop a pedagogy that acknowledges all forms of learning science and student identities. PSSTs do have initial, albeit novice, understandings about pedagogy to support diverse learners, as *Virginia*’s statement earlier had shown. Critiquing science lessons, both peer taught and from examples on video, became a critical tool in this development, as the PSSTs listen to feedback from other novices that have their own notions of what constitutes good science teaching. *Philip*, for example, recognizes the need to use analogies after he watched a science lesson video:
Philip (08-30): “(The teacher) related (stoichiometry) to chocolate chips and M&Ms... for me to understand, I had a problem with visualizing something. Having a different mass or whatever related to the number of them there are... Looking at the scale of atoms, (using chocolate chips and M&Ms) can help you visualize that.”

Philip mentions that analogies were helpful for him when learning science content. This is not an isolated incident, as he brings up analogies again when critiquing a science lesson taught by myself, where I make a comparison between the energy lost by breaking a cracker and the energy lost by smashing a concrete block with a sledgehammer:

Philip (09-04): “I think a really good thing was relating the not created nor destroyed thing, about how (energy is) conserved. (Breaking the) crackers and (smashing the concrete) block were very similar in the function. That made a lot more sense, (understanding) the energy going into breaking those things up.”

In both of these statements, Philip mentions the use of analogies within two very different science lessons, and how using analogies helped him to understand the science content better. It is evident that Philip values using analogies while learning science content, and he plans to integrate it into his pedagogical methods. This phenomenon is not unique to Philip, as other PSSTs express their own values while critiquing peer teaching lessons. Jeffrey, for example, believes strongly that discussions can be a useful tool to use within science lessons:
Jeffrey (09-06): “I really liked how you guys were setting up for a class discussion when we had conflicts. But I think you could have developed that a little more. Instead of just giving us the answers, you should (try using statements like) ‘Let’s as a group come together. What’s our consensus? Let’s come up with our own definition. Let’s revise this definition.’ And so I think that would have been a nice closing for (your lesson).”

Jeffrey here suggests that, during a peer teaching lesson, the PSST should have expanded upon their class discussion when there were disagreements on the correct answer. Jeffrey values the use of discussion within science lessons. This is evident because Jeffrey suggests using discussions when critiquing peer teaching lessons taught by many other PSSTs. In the following four examples, Jeffrey brings up the use of discussion in peer teaching lessons; either complimenting the PSST for their use, or suggesting to the PSST they need to use it more within their lessons:

Jeffrey (09-13): “(The Peer Teacher) did a really good job of... when someone made a statement, not answering it and saying yes. Also, by asking other people to expand upon (their statement), it caused discussion amongst us which I thought was really good.”

Jeffrey (09-18): “At the end, you’d ask a question and we’d answer. And you said ‘Oh yea good,’ then you jumped into explaining (the answer). Maybe try and get more discussion amongst the students so it’s on them.”

Jeffrey (09-25): “After the first activity, you ended it and there was no ‘Hey lets go over what you did’ kind of thing. And I thought that would have been a good opportunity, get people to talk about what they did, instead of just kind of ‘Okay we’re going to move onto something else.’"
Jeffrey (09-27): “Try and do a little less one-and-done in terms of: you ask a question - student answers – (you respond with) good, and then you go into a big explanation. Maybe ask for other answers. Or if you were looking for more, ask more; because a lot of time you expand upon what people say, but maybe students will be able to do that as well. And that would be a good opportunity to get less teacher-center and more student-center.”

Similar to Philip’s values of using analogies within science lessons, Jeffrey’s critiques of peer teaching lessons show that he values student-student interactions and generating discussions. This is common with other members of the class as well. Each PSST tends to focus on specific criteria they feel encompass proper science instruction. While these criteria should be encouraged, they are narrow in scope and need to be expanded upon. With this in mind, the task of the intervention then begins with encouraging Philip to value student-student interactions and generating discussions while also encouraging Jeffrey to value using analogies. Critiquing peer teaching lessons becomes a useful tool, as other suggestions are made to improve a PSST’s science lesson. In addition, the instructor can begin to build upon these basic understandings of pedagogy drawing on research-based strategies to support diverse learners and get the PSST to critically think about culturally relevant pedagogy. While PSSTs continue with their peer teaching activities, they need to be exposed to different science teaching strategies to improve their instruction. To do so, the next phase of the intervention had PSSTs examine differentiated instruction (DI) within the science classroom.
Having PSSTs think about differentiated instruction within science classrooms became the next phase of the intervention. This phase of the intervention sought to have PSSTs think about diversity in terms of personal interests and achievement levels. Readings on differentiated instruction in science education, classroom discussions, and PSSTs modifying their lessons to incorporate differentiated instruction were the activities included during this phase of the intervention.

Before discussing differentiated instruction, PSSTs read journal articles that discussed what DI was, how it can help science instruction, and gave a few examples of what it looks like within the science classroom. While these articles were intended to stimulate discussion, PSSTs tended to mimic the examples given within the article. This was an unexpected trend, as the intent of reading these articles was to have the PSSTs expand and improve upon these examples. During an activity where PSSTs were asked to modify an existing lesson plan to incorporate DI, *Virginia* begins to think about the different types of learners within her classroom and how to modify her instruction to suit the needs of these diverse learners:

*Virginia* (09-13): "Our lesson was on the kingdoms of life, and we wanted to have them all do creative things but do it in different ways. So we thought of making a kingdom flag for the people that are more visual, or they could present their kingdom flag with whatever kingdom they had (inaudible) that sort of stuff. For the more note taking learners, they could write a decree on what their kingdom was, the rules to be in their kingdom, that sort of thing. The hands-on learners, they could do a skit or a puppet show type of thing... so just varying the type of assessment but to get the same lesson."
Here, *Virginia* builds upon her initial understanding of the types of learners in the classroom and begins to think about how to better suit the needs of these learners. Again though, these ideas are a superficial understanding of diversity in learning science, as *Virginia* thinks solely on modifying her assessment strategies rather than the entire lesson. In addition, *Virginia* proposes superficial ideas that would not be suitable instructional methods within a science classroom. As mentioned previously, these ideas stem from the previous readings on DI where similar methods were chosen within a biology lesson. This was an unexpected trend, as the intent of the readings was to familiarize PSSTs with the concept of DI while also having them improve upon the methods discussed within. This trend was not limited to *Virginia*, as other PSSTs in the class also tended to focus on this particular facet of the reading. *Philip* also proposed similar modifications for DI as *Virginia*, which was to have the students write or draw when sharing their answers:

*Philip* (09-13): “Our one activity was breaking down a sub and its parts, and saying that’s lettuce, that’s a producer… and then, for people who, like to write, they could write a description of, a paragraph or whatever of, what they found and whether that’s a carnivore, things like that. Or you could draw a picture of each kind of ingredient or piece of food and label that as what level it would be as well.”

*Philip* mirrors *Virginia’s* understandings about DI and ways it can be used within the science classroom. His examples mimic *Virginia’s*, that these are superficial ideas and only modify assessment strategies rather than the entire lesson. As stated
previously, this was an unexpected trend; however, while these are novice understandings of modified pedagogy and DI, PSSTs begin to expand their pedagogy beyond their own previous experiences learning science. As PSSTs participate in activities designed to support diverse learners, they begin to appreciate how modified pedagogy can increase student motivation and engagement in science.

The next phase of the intervention discussed diverse learners, having PSSTs participate in activities such as: reading journal articles about diversity in learning, classroom discussions on diverse learners, and modifying existing lesson plans to incorporate strategies intended to support diverse learners. As the PSSTs participate in these activities, they begin to develop an appreciation for how considering these strategies can increase student motivation and engagement. For example, Karen mentions how providing students multiple options for learning science content can be more interesting for the student:

Karen (09-13): “Something might be more interesting for them to do... I would be interested in doing this, like this activity, because I would be able to choose what I wanted to do.”

During the class discussion, Karen here mentions how considering strategies to support diverse learners can help students become more interested in learning. Sharon expands upon Karen’s notion, and how important it is to consider student interest when designing pedagogy:
Sharon (09-13): “If I’m more interested in it, then I’m going to learn the material better. So if I’m doing something where I don’t have any interest in the project, then I just want to get it over with.”

Both Karen and Sharon value student interest when learning science, and they identify these strategies as a tool that can help increase this interest. In addition, Karen recognized that providing different options for students to learn is another strength of these strategies. Robert also recognized this strength, as he mentions here:

Robert (09-13): “It lets students take real control of what they learned and how they learn it.”

Robert recognizes that giving students control of their own learning is another strength of strategies to support diverse learners. These statements show that PSSTs view modifying pedagogy to support diverse learners a helpful tool for increasing student motivation and engagement.

Overall, prior to their field experience, PSSTs recognize that science content can be presented and taught in multiple ways to a learner. These initial views, however, are challenged when PSSTs work with children in their field placements, and this results in the PSSTs being classified into two groups in terms of their practices regarding modifying pedagogy to support diverse learners.
After Field Experience (Positive Experience Group)

Overall Findings

One group of PSSTs had a positive experience when attempting to modify their pedagogy to support diverse learners. Reasons they cited for success included: (1) reflecting upon unsuccessful lessons to identify what went wrong; (2) becoming adaptive to the needs of the students; and (3) focusing on the teacher or the pedagogy as the agent rather than the student.

These findings were self-reported during their field experience. Many PSSTs indicated how integrating multiple pedagogical strategies into their curriculum helped increase student achievement. Each week, PSSTs were asked to write blog entries focusing on particular issues within science education, and then reply to the blog entries of two other PSSTs. One topic asked how the PSSTs (or their mentor teacher) reacted when teaching an unsuccessful lesson to their students. Responding in their blogs, many PSSTs cited how modifying their instruction, a technique discussed during our intervention activities, was helpful to use during their field experience. Daniel, for example, wrote in his blog about how he used many different strategies when attempting instruction:

Daniel (11-05): “So in order to get my students to be as knowledgeable on trigonometry as possible I tried tackling the subject in many different ways, with guided instruction, inquiry based lessons, explicit instruction, as well as peer intstruction (sic). Apparently this all worked out well because by the end of the week, when the students were quizzed... they all did very well.”
Here, Daniel shares a positive experience he had when integrating strategies he learned during the intervention, and observed how it helped student achievement (Note: Daniel is a Physics teacher, so some of the lessons he taught were more math based lessons). While he doesn’t explicitly state it, Daniel used strategies that support diverse learners in the science classroom. He mentions that he used guided instruction, inquiry based lessons, explicit instruction, and peer instruction. While Daniel has his own preferred way of learning, he recognizes that his students have their own preferred way of learning. To support his students, Daniel integrated many different pedagogical models when teaching. Like Daniel, other PSSTs recognize the need to use multiple teaching strategies in order to support the diverse needs of students. Rebecca, for example, stresses how important it is to consider the needs of the students when designing pedagogy:

_Rebecca_ (11-05): “In the end, all we can do as teachers is create as many opportunities for students to learn as possible in the very little time we have. Whether its through lecture, lab, group activities, review games, etc., each presents a new chance for students to grasp the material.”

_Rebecca_ shares her value of making every effort as a science teacher to support all students. The values that Daniel and Rebecca express here move beyond their own past experience learning science. These PSSTs recognize that science instruction is not a one-size-fits-all approach; rather, they must modify their instruction to suit the needs of their students, and use multiple approaches when presenting science
content. This recognition is a core foundation of modifying pedagogy to support diverse learners. While it is helpful to know that PSSTs were able to use modified instruction successfully within the classroom, identifying reasons for this success is much more important to consider. Therefore, a more detailed analysis was explored to identify these specific reasons for success in modifying pedagogy to support diverse learners. Three specific reasons for success were found: reflecting upon unsuccessful lessons to identify what went wrong, becoming adaptive to the needs of the students, and focusing on the teacher as the agent of change rather than the student.

**Using Reflection to Modify Instruction**

One reason for success is that PSSTs used reflection (Howard, 2003) as a useful tool when attempting to modify their instruction to support the needs of all learners. Reflections upon lessons was a major component of the intervention program, and evidence from the PSSTs peer teaching exercises and blogs written during their field experience shows that reflection is a crucial tool needed for PSSTs to advance their understandings of how secondary students view the science content PSSTs teach. Rebecca, for example, wrote in her blog about how reflection was useful for her to use whenever she taught an unsuccessful lesson:

*Rebecca (11-02)*: “So when I do have an unsuccessful lesson I definitely take some time to figure out where it went wrong… when a lesson does go bad I reflect on the moments where I lost confidence or at what point the students were lost… I am still not very good at pulling out plan B and trying something new on the spot that could help (my students). So, as of now
I take the time to reflect (sic) on specific moments students were lost, and see how I can adjust whatever part of the lesson was going on at the time to see if something can be reworded, added, or removed."

Here, Rebecca shares her experience of using reflection to help adapt to the needs of her students. During the intervention, one topic of discussion within strategies to support diverse learners was how to react when a lesson is unsuccessful. Rebecca here draws upon that discussion and recalls how reflection is a useful tool when attempting to modify instruction to better suit the needs of her students. Other PSSTs shared their experience using reflection while teaching at their field experience. Jeffrey, for example, mentions during a class discussion how he modified his instruction between his classes when he recognized unsuccessful portions. Jeffrey used reflection as a tool to help modify his lesson for his later classes:

*Jeffrey (11-13):* "I realize that I really like teaching in class more than once... the first period class was just that class that would sit there and go (*Jeffrey makes a blank stare face*) for everything. I put up a slide of ‘The Element of Surprise’ and it was ‘Ah’, and they just sat there. And I was like ‘Really?! Come on that’s funny!’ And so I tried to do an activity, I want to get them doing something because they’re just so dead to the world... And I explained it and maybe I didn’t explain it all that great, but they were just like ‘Man this activity sucks, I hate this!’... So I completely I did it for the second time I was teaching it and I made example cards (this time)... just, like, funny stuff. And the second class ate it up, they were laughing and they had a good time. And they got uber-competitive... It was a lot of fun to see them actually get into it and actually do something.... I’m glad I have the time in between, but I like thinking ‘That did not go well at all, what can I do differently?’"
Jeffrey used reflection between his classes to modify his lessons based on what was unsuccessful from his earlier classes. Like Rebecca, Jeffrey found reflection to be a critical tool to use within science instruction. While Rebecca used reflection between days to modify her single class, Jeffrey used it during the day to modify the second of his two classes. Reflection is a powerful tool to use within science instruction. Both Jeffrey and Rebecca address the importance of how helpful reflection can be on their lessons. Here the claim could be made that the deeper, more thoughtful a PSST reflects on their lesson, the more successful they become in adapting to the diverse needs of their students.

**Being adaptive to the needs of the students**

Another reason for success is PSSTs use adaptation when attempting to modify their instruction to support the needs of all students they teach. Adaptation was an important component of the intervention, as PSSTs need to recognize when a lesson is unsuccessful, concede that the format of the lesson is the issue, and modify their instruction to better suit the needs of their students. Karen, for example, writes in her blog how important she found adaptation when she attempted to fix an unsuccessful lesson:
Karen (10-31): “Adaptation is really the key to fixing an unsuccessful lesson. Even sometimes during the lesson, I can tell that I’m losing the attention and understanding of some students, so I know that I need to come up with a quick way to re-engage them. I think that as long as you accept that a method is not working, and move on, you can fix the lesson.”

Karen here mentions how important adaptation was for her when fixing an unsuccessful lesson. Of particular note is her final sentence, where she recognizes that PSSTs need to accept when a method is not working. While PSSTs accept that the reason a lesson is unsuccessful is because of their own teaching methods, responsible PSSTs will react and modify their instruction to better suit the needs of their students.

Adaptation is closely related to the first reason for success: reflection. Without reflecting deeply on their lessons, PSSTs will not be able to adapt to the needs of their students. Conversely, reflection becomes meaningless without PSST acting on this knowledge and adapting their future lessons.

**PSSTs are an agent of change**

The final reason for success is that PSSTs attribute the lack of student success to themselves or the pedagogy as an agent rather than the student. In other words, if the PSST teaches an unsuccessful lesson, the fault lies with the PSST rather than the student. During one activity in the intervention, graded assessment samples from secondary school students were given to the PSST to analyze. PSSTs were asked for their impressions to discuss within small groups and as a whole class. During this activity, Allen notices how many of these students scored low on the assessment.
*Allen* then mentions that he believes the teacher was at fault for the low scores, rather than that of the students:

*Allen* (09-04): “Wait, did anybody get an A? Then you know what I blame that on? The instruction... I would say that’s an instruction issue. Because I mean if you’re raising that many Fs... And I don’t think it was as much the students as it was the teacher... I think it was the teacher taught the material poorly... Just looking at it there were a lot of bad grades.”

*Allen* here believes strongly that the teacher was to blame for the students not understanding this content. During this activity, PSSTs only analyzed a written assessment activity; they did not observe the teacher’s instruction. Even with this in mind, *Allen* blames the teacher’s instruction for the low assessment scores. As PSSTs believe that they are at fault for a student not understanding the content, they will modify their instruction until they see an increase in understanding.

Like *Allen*, *Travis* recognizes the responsibility he holds as a teacher for all of his students to understand the content. During his field experience, he mentions this responsibility while writing in his blog:

*Travis* (11-01): “It can be kind of frustrating when it is a concept I believe should only take a day or so to go over but it ends up taking a week. However, it is my responsibility to teach them the lessons I create and make sure they understand the material.”

*Travis* here does express some frustration when he had difficulty teaching a concept. However, he recognizes his responsibility as a teacher, that he must do what is necessary for all of his students to understand the content. This responsibility goes
beyond what Allen had mentioned. As Allen mentions the responsibility of an unfamiliar teacher, Travis mentions his own responsibility. This is important to recognize because Travis continues to feel this responsibility even after feeling this frustration. In general, it is much easier to blame another individual rather than accept the blame yourself. This applies not only to blaming other teachers, but also by blaming the students for not understanding or being interested in the content. Travis’ statement shows he holds this responsibility even after teaching.

Teachers as the agent of change is explored more with the unsuccessful group, but it is evident that the moment a PSST blames the student for not learning the content, the PSST stops to make additional efforts to support this student. While the PSST believes that they are the reason for unsuccessful practices, he or she feels the responsibility of teaching all students and will adapt their practices to better suit the needs of their students.

**Conclusion**

As seen above, this first group of PSSTs had a positive experience when attempting to modify their pedagogy to support diverse learners. They were successful because they reflected on their unsuccessful lessons to identify what went wrong, became adaptive to the needs of their students, and attribute the lack of student success to themselves or the pedagogy as the agent rather than the student. These three reasons: reflection, adaptation, and responsibility, are all closely related to one another. They become a process of working towards a critical consciousness of developing culturally relevant pedagogy. Reflection supports
science teachers in being critical of the ways in which science content is taught, which is especially important to use when cultural differences between teacher and student negatively impact student achievement. In order for CRP to be successful, science teachers need to identify how their instruction acknowledges the cultural understandings of their students. After doing so, science teachers can adapt their instruction to better suit the needs of culturally diverse students. However, all of this can only be accomplished if science teachers take responsibility for learning about the cultural understandings of the students they teach and make an effort to change their own practices to support these cultural understandings. Reflecting upon lessons, adapting to the needs of students, and being an agent of change are all crucial tools to use for the development of CRP.

**After Field Experience (Negative Experience Group)**

**Overall Findings**

A second group of PSSTs, in contrast, experienced difficulty developing and enacting their pedagogy to support diverse learners. There were multiple causes for their difficulties, including: (1) their belief that some science content can only be taught one way, and that students need to adapt to the curriculum, rather than vice versa, in order to become successful in science; (2) resistance by students to participate during the PSST's lesson, which PSSTs indicated was due to laziness or disinterest in the content; and (3) the PSSTs using repetition as a form of modified pedagogy.
Belief that science content can only be taught one way

Some PSSTs were unable to make adjustments to their pedagogy due to a belief that some science content can only be taught one way. This belief does not necessarily encompass all of the PSSTs’ pedagogy; the belief may be limited to specific lessons or content. Jeffrey, for example, writes in his blog about his attempt to support diverse learners. The classes that he mentions were difficult to adjust based on the content:

Jeffrey (11-06): “I have tried to use (pedagogy to support diverse learners) in the classes where I can, but again these lessons I have been teaching have been very math based or just fact based.”

During Jeffrey’s field experience, he did not recognize an opportunity to modify his pedagogy to support diverse learners during his lessons that were very math or fact based. New teachers will certainly experience difficulty in modifying their pedagogy with certain content, as they are overwhelmed with responsibilities and have limited time to develop lesson plans. While math-based lessons can incorporate CRP (such as by making connections to students’ home lives, encouraging the ideal that all students can achieve within the classroom, and reinforcing its necessity to be successful), it is Jeffrey’s stagnation in making any changes to his practices that is important to consider within this discussion.

However, the PSST is not always responsible for this limited view of science instruction. This belief, that science content can only be taught one way, may also be due to interference from a mentor teacher. Erika, for example, mentions during a
class discussion her difficulty in bringing her own pedagogy into the classroom when met with resistance from her mentor teacher:

_Erika_ (11-13): “I had to teach photosynthesis in two days. And I guess I was just really shocked because, one of my biggest issues was I wanted to really go in depth and teach them everything and it wasn’t working. (My mentor teacher) said, ‘Erika, no, they aren’t listening to you anymore.’... And I wanted (the students) to move really slow and do labs and stuff, and (my mentor teacher) said, ‘No, you just have to get through the material, cut out your fun stuff because you have two days, get through the material and just lecture them.’ So it was really bad because I’m up there and trying to explain (the content). And some (students) were sleeping... My biggest struggle was simplifying all the material because, the way that (my mentor teacher) teaches it, it’s so basic... And I wanted to go (more in depth), and (my mentor teacher) yelled at me, ‘No, you have to cut that all out.’ That was a shock to me, how them being honor students in ninth grade and all that needed to be cut out.”

_Erika_ here had a lot of interference from her mentor teacher. While _Erika_ wanted to use her own pedagogy, she was limited by her mentor teacher on what she had to teach, how in depth she could go, and how she had to teach the material.

Interference from a mentor teacher can have huge implications on how PSSTs view science pedagogy. As _Erika_ mentioned, she wanted to bring new pedagogical strategies into her instruction but was restricted by her mentor teacher. _Erika_ was not the only PSST that experienced this resistance, as other PSSTs also shared their frustration with how their mentor teacher restricted the way they wanted to teach. _Paul_, for example, mentions how his mentor teacher plan teaches lessons at his field experience during a class discussion:
Paul (11-13): “I was really surprised at how little effort some of the teachers put in. There were a lot of teachers in my school, especially my mentor, who tried to do the bare minimum. The school curriculum, they got a grant for pushing reading and writing. So my mentor teacher decided to just do reading and writing every day. So every day they’d get the book, they’d have to read pages one hundred to one ten, and then they have a worksheet to fill out. It was literally every day: you come in, open up the book, do a worksheet, go home. And he didn’t do anything, he told me that you shouldn’t have to plan for a lesson for more than ten minutes for any class... and he said you shouldn’t have to take anything outside of three p.m. Once the bell rings and the day is over, go home and that’s that. When I tried to do more he’d be like stop, be like you’re doing too much.”

Paul experienced frustration at how little he felt his mentor teacher put into instruction. Whenever Paul tried to teach a lesson in his own way, his mentor teacher would stop him. Mentor teachers have a large influence over how PSSTs view and design pedagogy. Both Erika and Paul comment on how they had conflicts with their mentor teachers when trying to teach. In addition, these comments reflect Erika and Paul’s views after only a few weeks working with their mentor teachers. When Erika and Paul are required to work three months with their mentor, their views on science instruction will be challenged greatly. The longer PSSTs work with their mentor teacher, the more likely they will adapt to the instructional strategies their mentor uses.

This trend continues, as PSSTs do not necessarily adopt practices that reflect their own expressed values. Reasons for this disconnect range from resorting to more comfortable but less effective pedagogical strategies or experiencing friction
between a mentor teacher and the PSST. *Paul*, for example, reflects on a peer teaching lesson he had just taught. While he valued using wait time in his lesson, he resorted to a more comfortable strategy when he became nervous:

*Paul* (09-11): "I completely forgot about the wait time. And that's something that I was stressing myself coming in, make sure you do wait time. And then, once you’re up there, it’s really easy to just (forget it)."

Wait time was a new concept to *Paul*, but he expressed his value of using it within his lessons. However, when *Paul* felt anxious, he resorted to his more comfortable method of calling on students.

*Rebecca*, like *Paul*, was not able to express her values of science teaching. Unlike *Paul*, whose resistance was an internal factor (i.e. his anxiety), *Rebecca* was resisted by her mentor teacher, an external factor. She mentions this resistance during a class discussion:

*Rebecca* (11-13) reflects on her field experience: “That’s kind of a concern I have... There’s a generation gap I want to call it between our mentor teachers and us... they kind of just want to get through the material, do worksheets, they don’t want to do a lot; but we come in with all these creative activities, and we want to do all these things.”

Many of the PSSTs felt resistance between how they wanted to teach and how their mentor teacher wanted them to teach. *Rebecca* shares this concern, as she wishes to use her own pedagogy within the classroom.
This belief, that science content can only be taught one way, was a barrier for PSSTs when developing CRP. When a student experienced difficulty during a science lesson, the PSST did not provide alternative performance objectives that would have helped the student. Mentor teachers that exhibited this belief also became a barrier for PSSTs when developing CRP. Mentor teachers restricted the ability of PSSTs to use strategies necessary for CRP. While either the PSST or the mentor teacher held this belief, in both cases it became a barrier for the development of CRP.

This became a factor that hindered the development of CRP. As such, it has been added to the PSSTs’ CRP Decision Making Process flowchart.

**Student resistance to instruction**

Another difficulty PSSTs faced when modifying pedagogy to support diverse learners is student resistance to instruction. *Erika,* for example, writes in her blog about how difficult she found it to teach her students, even after attempting to modify her pedagogy multiple times:

_Erika_ (11-03): “We have showed diagrams, taught the material twice, reviewed the material four times, we have shown videos, interactive moving diagrams, drew examples on the chalkboard, made them do a project where they had to make a comic strip showing the different types of transport, and did review stations with crossword puzzles and other fun activities. Most of the class has gotten the material by now, but there are still students who
are struggling. Keep in mind that these are all honors students. We have even given them an exact answer on the test before and some of them will still get it wrong! I’m starting to think that some students just won’t put in the effort to do well.”

Here, Erika attempted multiple times to modify her instruction, but found no change in student achievement. This raises an issue with modifying pedagogy to support diverse learners. After a certain number of attempts, the PSST will experience a “breaking point,” where they will stop viewing themselves as unsuccessful and instead place the blame on the student. This is related to the successful group of PSSTs that saw themselves as the agent of change. Within early attempts, the PSST will use reflection and adaptation to tailor to the needs of the students, while also holding the belief that the teacher is the agent of change within a classroom. This will continue until, eventually, the PSST reaches the “breaking point.” This breaking point may be due to the PSST reflecting on their lesson and not identifying anything that needs improvement, or the PSST not able or willing to adapt their instruction any further, or the PSST placing the blame on the student, or a combination of all three.

**Using repetition as a form of modified pedagogy**

The last difficulty PSSTs found when attempting to modify pedagogy to support diverse learners is using repetition as a form of modified pedagogy. This stemmed from a misunderstanding on the part of the PSST when discussing modifying pedagogy to support diverse learners. For example, Audrey writes in her blog about how she uses this strategy:
Audrey (11-01): “In most of the lessons Mr. Wilson and I teach, we try to use (pedagogy to support diverse learners) as well as a lot of examples and practice to make sure the students see the material in several different ways. Whenever I teach a skill to the students, I make sure to use the Model-Prompt form of teaching where I first model the skill and do several examples, and then I have them tell me how to answer a couple examples, and I prompt them with the instructions, and then I have them do a couple on their own.”

While Audrey mentions that she modified her instruction, her statement indicates the contrary. Audrey mentions that she used the “Model-Prompt” form of teaching, did several examples, and then had her students do some examples on their own. Rather than modifying her instruction, Audrey has her students perform the same task multiple times.

Daniel as well had this misunderstanding of modifying pedagogy to support diverse learners. Like Audrey, he uses repetition as a form of instruction, something he mentions when writing in his blog:
Daniel (11-05): “I know that I have to give my classes instructions multiple times for them to fully understand what is being asked of them, even when the instructions are clearly written on a worksheet. I know one worksheet I gave out the other day I explained to the class and when I walked around the classroom checking work I saw that multiple students were still doing it wrong, even with the both vocal and written instructions.”

Daniel here uses repetition to go over the instructions for an activity. Even after reiterating these instructions, he notices some students still are doing it incorrectly. This would have been an opportunity for Daniel to modify his instruction to support diverse learners, but he does not recognize this opportunity.

This misunderstanding on the part of the PSST has unfortunate consequences when attempting to modify pedagogy to support diverse learners. Repetition is not a component of modified pedagogy. In addition, using repetition will exasperate the PSST breaking point. As the PSST consistently repeats the same
instruction multiple times with no change in student achievement, eventually the PSST will break and place the blame on the student(s).

**Conclusion**

In conclusion, this group of PSSTs experienced difficulty developing and enacting their pedagogy to support diverse learners. The primary reasons for their difficulty were: (1) their belief that some science content can only be taught one way, and that students need to adapt to the curriculum, rather than vice versa, in order to become successful in science; (2) resistance by students to participate during the PSSTs’ lesson, which PSSTs indicated was due to laziness or disinterest in the content; and (3) the PSSTs using repetition as a form of modified pedagogy.

**Summary: Pedagogy To Support Diverse Learners in the Classroom**

While PSSTs shared a common value of modifying pedagogy to support the diverse ways students effectively learn science, their field experience acted as a catalyst that separated the PSST into two groups: those that observed an increase in perceived student achievement after modifying their pedagogy to support diverse learners, and those that experienced difficulty attempting to modify their pedagogy to support diverse learners. Reasons for success included: (1) reflecting upon unsuccessful lessons to identify what went wrong; (2) becoming adaptive to the needs of the students; and (3) attributing the lack of student success to themselves or the pedagogy as the agent rather than the student. However, other PSSTs experienced difficulty modifying this pedagogy due to: (1) their belief that some
science content can only be taught one way, and that students need to adapt to the curriculum, rather than vice versa, in order to become successful in science; (2) resistance by students to participate during the PSSTs’ lesson, which PSSTs indicated was due to laziness or disinterest in the content; and (3) the PSSTs using repetition as a form of modified pedagogy.

At the start, the PSSTs’ initial views on culturally relevant pedagogy have a strong influence on their attitudes and pedagogy before interacting with students. When the PSST is successful in using diverse learning strategies to address aspects of CRP, he or she will attribute that success to either the pedagogy or to the students. In the case of the pedagogy, the PSST integrated strategies learned from developing CRP from the intervention and saw how it can be an agent of change for diverse students. In the case of the students, the PSST believes that the students were responsible for success, regardless of how the science content was taught. However, when the PSST is unsuccessful in using CRP, he or she will again attribute that failure to either the pedagogy or to the students. If the pedagogy was to blame, the PSST will reflect on their practices, adapt their instruction, and attempt to teach the content again. This process will repeat multiple times until, eventually, the PSST will reach a breaking point and place the blame for failure on the student. When this happens, the PSST will move on with instruction without further attempts to support struggling students.
How do pre-service science teachers view the importance of culturally relevant pedagogy for supporting student learning? How do their practices in the field change these initial views?

**Overall Claim**

Pre-service science teachers acknowledge that understanding the culture of students within science classrooms is necessary in order to build a rapport and engage students in learning science content. However, after working with secondary school students, some pre-service science teachers: (1) continue to hold onto a naïve view of how culture influences science instruction; and (2) focus on the negative behavioral aspects of the cultural differences between themselves and the students without attempting to discover the root cause for these behaviors.

**Prior to Field Experience (Initial Views on Culture)**

**Defining culture**

Pre-service science teachers were asked to define culture in their own words during the first interview of the semester. It was necessary to determine whether the PSSTs held a similar conception, in general, to my own of what defines culture. If not, any conversations about culture between the PSSTs and me would have created misunderstandings due to our disparate conceptions.

While each response varied by the specific examples of culture, PSSTs generally identified culture as the factors that influence the way in which an
individual views and interacts with the world around them. *Sharon*, for example, focused on the beliefs and traditions of a students' locale:

*Sharon* (09-21): “I guess their beliefs and where they came from, traditions... I think we all have a cultural background so, I guess, just yea, where they came from, background.”

*Sharon* here mentions her own views of what defines culture. *Sharon* particularly focused on an individual’s geographical location as the primary influence of what influences cultural values. Like *Sharon*, *Karen* mentions similar characteristics when asked to define culture:

*Karen* (09-17): “I think it's where your family comes from and... the traditions that you grew up doing. Maybe the language you grew up speaking... like just how you view the world because of how you were brought up.”

While both *Karen* and *Sharon* identified an individual’s locale as a cultural factor, *Karen* was able to expand deeper on these characteristics to include the larger social context of culture. *Karen* here identified family, traditions, and language as cultural factors. In addition, *Karen* mentioned how culture affects an individual’s actions: In how an individual’s upbringing influences the way in which he or she views the world.

While *Karen* and *Sharon* were able to identify specific criteria as cultural factors, others experienced some difficulty trying to define culture. For example, *Erika* mentioned an individual’s socio-economic status when asked to define culture:
Erika (09-17): “Umm, probably, like, socio-economic status. I feel like that’s a big one, because... I know that’s not really cultural; but, I just feel like people have a lot of money; or, like, come from families that are more involved in their lives. It’s, like, they’re taking them on trips. They see history hands-on, they see nature hands-on. Or even if you live in a suburb and you have woods in your backyard, you can go out and explore all those. But if you’re in inner-city where there’s no green anywhere, it’s like you don’t have enough money to go out, experience any of that, or you don’t see any wildlife, then you’re already a step below the people who see it.”

Erika’s response is interesting to note because, while she did not specifically identify socio-economic status as cultural, she did recognize its importance and how it could affect science instruction. Erika brought up the issue of opportunity, as she mentioned that some students would not have the same opportunities as their peers due to limiting factors such as location or economic status. Erika’s response also indicates that she views urban environments as a deficit rather than acknowledging the positive opportunities these communities can provide, such as being able to access museums and science centers. She elaborated more on opportunity when discussing a book she had recently read:

Erika (09-17): “I just read a book, I think its called ‘The Last Child in the Woods’.. (The author) was going on about how it’s important for kids to experience nature for cognitive reasons. Kids who don’t, they’re like more depressed and they lose interest. So it’s like, depending on where you live or what culture you’re from, it definitely affects your interest in science or how much you care. Cause (the students) not used to it just, like, lose interest.”
Erika initially possessed a strong belief in giving all students the opportunity to learn and enjoy science. While Erika did not identify socio-economic status and opportunity as cultural factors, she still valued their important in science instruction. This is important to consider because PSSTs may not identify specific factors as being “cultural,” they still value how these factors influence student understanding in the same way as if cultural. Therefore, the analysis for this study expanded its focus to include factors that would be classified as cultural from academic literature (see Chapter 2), and not solely what PSSTs identified as cultural. This will be especially important to consider during the analysis of how PSSTs react to the negative behavioral aspects of their students during field experience.

**Building a rapport with students**

Pre-service science teachers initially view culture’s role in science education as a way to build a rapport and connect to the interests of their students. These views are commonly mentioned when critiquing peer-teaching lessons, as PSSTs would identify attempts their peers would make to build a rapport with the class. Karen, for example, mentioned how thoughtfulness can positively influence students’ attitudes towards science lessons:

Karen (09-11): “I really liked at the beginning how you (Paul) said ‘Good morning, how was everyone’s weekend?’ It was nice because it was what we should be doing in an actual classroom, talking to us, waiting on the academic stuff just for a bit just to make sure everyone is feeling good about the day.”
Karen here mentions how she liked how the peer teacher (Paul) made attempts at the beginning of a lesson to build a rapport with the class. This is a minimal attempt, as Paul simply began his lesson by asking how the class is doing. However, it is important to note that this was one of the first peer teaching lessons taught by a member of the class. As the semester continued, other PSSTs began to expand upon their own practices based on the pedagogy used and feedback given by their peers. Other PSSTs adjusted their demeanor throughout the entirety of their lesson in order to provide students with a comfortable learning environment. Virginia mentions this as she compliments one of her peers (Daniel) on the way he conducted himself during the lesson:

Virginia (09-20): “And I think you (Daniel) developed kind of like a rapport with students, where you were still the leader of us, but we felt comfortable.”

Building a rapport with students was a critical component that the PSSTs considered within their pedagogy. This is evident because of PSSTs integrating specific strategies within their lessons (i.e. Paul and Daniel) and identifying their use within their peers’ lessons (i.e. Karen and Virginia).

In order for PSSTs to expand upon their own practices, the PSSTs must be given multiple opportunities to receive feedback from individuals they respect. Erika, for example, had also mentioned the importance of building a rapport with students while she critiqued a peer-teaching lesson:
Erika (09-25): “Whenever you (Rebecca) would ask us to do something, you would always say ‘please.’ My mother (an experience teacher) gives me that advice all the time. You don’t realize it, but with high school kids, the more you say please, they respect that and people respond to that.”

Erika mentioned advice given to her by her mother, an experienced teacher, about being a science teacher. Erika values the advice that her mother gives her, as there are multiple instances of Erika sharing her mother’s advice throughout the course. While PSSTs may have different reasons for valuing building a rapport with their students (e.g. Erika got advice from a family member who is an experienced teacher), all PSSTs value the importance of building a rapport with their students.

While the core teaching methods of PSSTs are similar to those of their own K-12 experience, this initial view of the importance of considering culture within science education gives an opening for PSSTs to begin to analyze how instruction needs to be diverse to support the diverse sets of learners within a classroom. These early views of building a rapport and engaging students are admittedly a naïve way to view the role of culture within science education. Cultural understandings not only influence the way individuals engage in science, but also influence the way individuals understand science. Science teachers need to critically deconstruct their curriculum to ensure that it supports all students in learning science. Building a rapport and engaging students are fundamentals within all education programs. Even so, these views are necessary for PSSTs to develop CRP;
without these views, PSSTs cannot properly engage culturally diverse populations by acknowledging culture as a crucial factor to consider within science education.

**Critically analyze the language used within science classrooms**

In addition to these early views of building a rapport with students, PSSTs began to critically analyze the language they used within the classroom and thought about how it impacted science instruction. Language within a science classroom can hold different meanings between the teacher and the student, and this disconnect can become exponentially more problematic when working with diverse populations. As such, I continually stressed the importance of considering the language we use within science classrooms during the intervention. As the intervention progressed, more and more PSSTs were able to critique the language their classmates used during peer-teaching lessons.

One way in which PSSTs consider the language they use is how language can unintentionally discourage students. *Paul,* for example, identified one statement *Erika and Karen’s* make during a team taught peer-teaching lesson:

*Paul (09-06):* “You (Erika and Karen) were talking about the misconceptions of the strawberries, and I noticed you said that we ‘messed up’ with the one thing. I think it just has a little more negative connotation than saying that we were misinformed. Saying we messed up implies that we were just flat out wrong.”

*Paul* here suggested that *Erika and Karen* should choose their words carefully, as they may unintentionally disengage students from the lesson. While *Erika and Karen*
did not intend to disengage the class, their statement had unintentional 
repercussions for the lesson they taught. This was not an isolated incident, as other 
PSSTs also began to identify the language used within the science classroom. Jeffrey, 
for example, critiques a peer-teaching lesson taught by Frank:

*Jeffrey (09-27):* “When you (Frank) said nerds... I call myself a nerd all the time. But I know
 I've read that, don't refer to people who are scientists or people engaged in science as nerds.
 Because, although we say it jokingly, it might impact (the students’) view of scientists. (The
 student may) think, 'Oh man, all scientists have to be nerds. And I’m not like (the teacher) so
 I'm not going into science."

*Jeffrey* notes here that, while *Frank* mentioned it jokingly, his view of nerds may not 
align with his students’ view of nerds. *Jeffrey* notes that this may disinterest his 
students in the lesson and from pursuing careers in science.

The second way PSSTs analyze the language they use is by how it can create 
student misconceptions. *Jeffrey*, for example, cautions *Robert's* about the phrasing 
he used during *Robert's* peer-teaching lesson:

*Jeffrey (09-13):* “And then also, careful with statements like ‘the pressure went out.’ You
 *(Robert)* said that a couple times, which might lead to some really bad misconceptions.”

*Jeffrey* identifies the language that *Robert* used during his peer-teaching and how it 
could be misconstrued by the students. Like *Jeffrey*, *Erika* mentions an instance 
where she misunderstood a portion of a peer-teaching lesson:
Erika (09-18): “On the worksheet, I don’t know if I just think differently than other people, whenever you said ‘why was one group favored over another,’ I was thinking, why they got the big fruits (and misunderstood what you meant)...”

Erika does disclaim that she may think differently than her peers, but mentions that some of the language used in the peer-teaching lesson confused her. While Erika doesn’t realize it, her statement is a fundamental understanding of developing culturally relevant pedagogy. Science teachers being able to acknowledge that they may think differently from their students is key component of Ladson-Billings’ framework (1995)

As seen above, PSSTs analyze the language used within their lessons in two ways: how it can create student misconceptions, and how language holds different meanings between the PSST and the student. The second way PSSTs analyze the language used within their lessons is particularly important for analysis. As PSSTs acknowledge diverse ways of knowing, they become more open to modifying their own instruction from what worked best for the PSST to what would work best for the student. For example, while results from early in the semester showed PSSTs believe students need to adapt to the curriculum to become successful in science, later on in the semester these notions were expanded to include methods that could be used to better guide the student towards acceptable practices in science.
Rebecca, for example, shows an expansion in her views of acceptable practices in science between early on and late in the semester. Early on during a class discussion, Rebecca mentions that there are specific acceptable practices in science, as she responds to the notion of diverse instruction in science:

*Rebecca (09-11):* “Not everything is going to be catered exactly to the (student's needs).”

This notion is expanded upon later in the semester, as Rebecca acknowledges the need to create many different opportunities for students to learn while responding to a blog post:

*Rebecca (11-05):* “In the end, all we can do as teachers is create as many opportunities for students to learn as possible in the very little time we have. Whether its through lecture, lab, group activities, review games, etc., each presents a new chance for students to grasp the material.”

Rebecca can be seen here to expand upon her idea of acceptable practices in science education. Early on, she held firmly onto her view of science education that the student needs to be able to adapt to the instruction. However, after the intervention Rebecca changes her view to be more aware of the needs of the students. These initial views are expanded upon as PSSTs begin to acknowledge the cultural understandings of their students and how modifying their pedagogy, based on cultural understandings, can better support student achievement.
However, after their field experience, the initial views of PSSTs diverged into two groups: a positive view on the role of culture with attempts to support all students, and a negative view based on self-reported observations of laziness and disinterest on the part of the student.

**After Field Experience (Positive View Group)**

**Overall Findings**

After their field experience, one group of PSSTs showed a positive view towards culture and how it impacts science instruction. These positive views included: (1) considering the difficult home lives of students; and (2) making an effort to engage disinterested students by adapting instruction to the needs of the students.

**Considering the difficult home lives of students**

PSSTs that had a positive view on the role of culture shared experiences of supporting students with difficult home lives and the ways in which they attempted to better support these students. *Karen,* for example, wrote in her blog about her difficulty in relating her instruction to the real lives of her students:

*Karen* (10-22): “I think that for using real life examples, you must give several examples so that all students can relate to at least one. This is tricky, especially if you aren’t from the area, so you don’t know a lot about what regular life is like or what kind of resources they have there.”
Making connections between students’ home lives and instruction is a familiar concept in science education programs. Helping PSSTs acknowledge this was an important part of the intervention, as it implies that science instruction is not universal, but rather needs to be adaptive based on the cultural understandings of the students. Karen’s statement touches upon a key component of developing CRP, as she recognizes that it is difficult to relate instruction to students’ interest without first knowing more about the community. This is another reason why the intervention focused on the foundations of developing CRP, as this will prepare PSSTs to teach within any community.

Similar to the multiple intelligences discussion, mentor teachers have a large influence on how PSSTs consider the home lives of the students they teach. In some cases, the PSST may disagree with their mentor teacher in how the home lives of students are considered within the classroom. Sharon, for example, mentions how she disagrees with her mentor teacher in her blog:

> *Sharon* (10-22): “I don’t think that my mentor incorporates the students’ home lives with their school lives, or at least not into the lessons...You really have to think about bringing the students’ personal lives into the classroom, but I think that if you can take the time to do it then the students will definitely benefit.”

*Sharon* here feels that her mentor teacher could do more to incorporate the students’ home lives within her lessons. As discussed earlier, mentor teachers have a large influence over the development of PSSTs. *Sharon* here presents a unique example of a PSST being able to hold onto her own values rather than adopt those of
her mentor. This was not common, as many PSSTs assimilate the practices of their mentor teacher. In some cases, this can be a positive experience, as Rebecca wrote in her blog detailing her mentor teacher’s extra efforts to consider the home lives of students:

Rebecca (10-20): “My mentor teacher told me about the many struggles the students have at home... All of these obstacles combined can really affect a student's ability to focus and learn in school, and it seems like it is a constant struggle getting through to them in the short class period we have. Taking this all into account, I learned that when a student doesn’t do his or her homework or does poorly on the exam, laziness or apathy shouldn't be the first assumptions we should be making as teachers.”

Rebecca praises the extra effort her mentor teacher takes when considering the difficult home lives of their students. Rebecca acknowledges that these struggles can affect a student’s performance, and that there are underlying reasons she must consider.

Karen, Sharon, and Rebecca all discussed the ways they consider the home lives of their students and how that affects performance in the science classroom. These PSSTs have adopted practices that are critical to the development of CRP. While these field experiences do not take place within culturally diverse school districts, the behaviors of these PSST mimic the strategies that educational researchers attest is important for developing CRP. Considering the difficult home
lives of students is a way PSSTs can successfully develop CRP, and as such has been added to the PSSTs’ CRP Decision Making Process.

**Engaging disinterested students by adapting instruction**

In addition to considering the home lives of the students they teach, PSSTs within this group began to think about the different strategies discussed within the intervention that would help instruction. Similar to the strategies used within modifying pedagogy to support multiple intelligences, PSSTs were able to engage disinterested students by adapting their instruction to support the needs of these students. *Robert*, for example, wrote in his blog about the academic diversity contained within his classroom. *Robert* mentions that his mentor teacher misses opportunities to support struggling students by using strategies discussed during the intervention:

*Robert* (10-30): “My mentor’s main method for helping alleviate this diversity is to continually emphasize the important points and go over a few problems for the students. This definitely does not work, as the struggling student, the student that does not pay attention, and the student whom does not care continually do poorly on exams. The bad part is that the struggling student does fine during class with some help. There are definitely missed opportunities for the instructor during these lessons. One thing he could do would be differentiated instruction.”

*Robert* specifically identifies differentiated instruction as a tool his mentor teacher could use to support the academic diversity within science classrooms. While *Robert*
does not give specific examples of how his mentor teacher could use differentiated instruction, *Sharon* mentions that even small considerations can really help students achieve in science. *Sharon* mentions that using encouragement and working one-on-one can engage students that seem to be disinterested in learning:

*Sharon* (11-01): ""Some of the problems that you talked about -- students not paying attention or not trying -- I have experienced in my classroom as well. However I did find that sometimes, those students just need a little more encouragement and one-on-one."

*Sharon* discusses how a student’s negative behavioral attitudes towards science can be better supported with encouragement and independent instruction. It is important to note that *Sharon* does not attribute these negative behaviors or disinterest in science as being a student problem; instead, *Sharon* makes an extra effort to support these students.

Both *Robert* and *Sharon* mentioned a common issue within science instruction; that is, having disinterested students within the classroom. However, *Robert* and *Sharon* mention adapted instruction as a tool they could use to engage these disinterested students. Cultural differences between teacher and student contribute to students become disengaged with a lesson (Ladson-Billings, 1995), and this group of PSSTs were able to use methods directly taken from the intervention to engage these students. Adapting instruction then becomes another component of the successful development of CRP.
Conclusion

This group of PSSTs empathized with students facing challenges and considered how those challenges impact science instruction. By considering the difficult home lives of their students and making an effort to engage disinterested students by adapting instruction to the needs of their students, these PSSTs have successfully used CRP strategies within their classrooms.

After Field Experience (Negative View Group)

While one group of PSSTs had a positive experience when considering culture, other PSSTs would focus on the negative aspects of diversity. As mentioned previously, PSSTs value and acknowledge the role culture plays within the classroom; however, these acknowledgements tended to be ignored when handling extreme cases of disinterest in science.

Before continuing this discussion, it is important to clarify what “disinterest in science” means within this case study. Data below will show examples of students not paying attention and/or not doing work, and how this group of PSSTs reacted. These behaviors may not necessarily be caused by cultural differences, as these PSSTs were not placed within culturally diverse school districts. The behaviors displayed below could instead be indicators of adolescent attitudes towards education at least partially created by their school experience. However, while these student behaviors may not necessarily be cultural indicators, how these PSSTs react to such behaviors are indicators of how they will succeed within culturally diverse
classrooms. For example, if the PSST makes no attempt to understand the home 
lives of students during his or her field experience, there is no indication that the 
PSST will make an attempt to do so when placed within a culturally diverse 
classroom.

**Naïve view of how culture influences science instruction**

One potential barrier for supporting PSSTs in developing CRP is a naïve view 
of defining culture and how it impacts science instruction. While PSSTs 
acknowledged the importance of considering the cultural backgrounds of the 
students they teach when developing pedagogy, how PSSTs define and view culture 
could potentially be an issue 
when trying to develop CRP. 
PSSTs tended to define culture 
using statistical data while 
overlooking or ignoring the 
larger community. During an activity that asked PSSTs to research a school district and report back what 
information would be valuable to know prior to the start of their teaching career, 
many responses reported demographic data (i.e. enrollment, racial diversity, socio-economic status, class schedules). While this is important information for beginning 
teachers to realize, none of the PSSTs recognized the larger community as a 
significant factor in a student's culture. As mentioned previously, understanding the 
surrounding community is a critical component of Ladson-Billing's CRP framework.
Focus on negative behavioral aspects

Another issue these PSSTs faced were observing the negative behavioral aspects of disinterested students. Audrey, for example, writes in her blog that she believes overall she has been successful teaching her students:

*Audrey* (11-01): “There have been some discrepancies (sic) of course, for the students who either don’t pay attention or who don’t try, but for those that are paying attention, the grades have been over-all good.”

Here, Audrey mentions that, with some exceptions, she was successful as a teacher. Of particular interest here is that Audrey overlooked the performance of students that “don’t pay attention or don’t try...” while she focused solely on how well the other students perform. This is problematic because, not only has Audrey classified some of her students as disinterested, she believes her performance has been successful because she was able to teach the students that want to pay attention.

In addition to Audrey, Erika observes the negative behavior that many of her students display while in her classroom. Erika writes in her blog that she believes many of her students are lazy:

*Erika* (11-03): “I have noticed a lot of diversity in my classroom. Some wealthier students are hard workers and some are complete slackers. That all depends on the parents. Some of our poor students do very well and some do not. What I find interesting is that most of them won’t turn in their homework, but they will do the best on tests and answer questions. They’re smart, but they are lazy.”
Erika’s statement classifies some of her students as lazy. Statements such as these become troublesome when developing CRP because PSSTs need to go beyond behavioral aspects and think critically about the root cause of these behaviors. Erika mentions that her students are lazy, but does not go further in depth of how to properly engage these students. This is not the only instance where Erika expressed frustration with her students, as she mentions this again during a class discussion later in the semester:

Erika (11-13): “It just surprised me, like, we were going over cell transport for weeks... we would even give them the exact question on the test, and these were honor students, and they would still, like, 75% of them would still miss the question... I don’t know, it’s just like, they just didn’t care, and some of them were honestly kind of lazy.”

These negative behavioral aspects are common in many adolescent classrooms, as students may be disinterested in learning science. However, the focus here should be on the PSST reactions to these negative behavioral aspects.

Conclusion
This second group of PSSTs focused on the negative aspects of diversity. These negative aspects were: (1) a naïve view of defining culture and how it impacts science instruction; and (2) focusing on the negative behavioral aspects of cultural differences without attempting to discover the root cause for these behaviors, or questioning their own judgment of these behaviors in a critical manner.

**Summary: Views on Culturally Relevant Pedagogy**

Pre-service science teachers initially acknowledge that understanding the culture of students within science classrooms is necessary in order to build a rapport and engage students in learning science content. Pre-service science teachers also begin to critically analyze how their language can unintentionally discourage students or create student misconceptions. While teaching secondary school students, pre-service science teachers had a positive experience when they: (1) considered the difficult home lives of students; and (2) engaged disinterested students by adapting instruction.

However, after working with secondary school students, some pre-service science teachers: (1) continued to hold onto a naïve view of how culture influences science instruction; and (2) focused on the negative behavioral aspects of the cultural differences between themselves and the students without attempting to discover the root cause for these behaviors.

**Summary**

The research questions for this study were:
1) How do pre-service science teachers view and design pedagogy while participating in an intervention designed to support the development of culturally relevant pedagogy?

2) How do pre-service science teachers view the importance of culturally relevant pedagogy for supporting student learning? How do their practices in the field change these initial views?

Figure 4.1a PSSTs’ CRP Decision Making Processes (Expanded from Figure 4.1)

Initially, all of the PSSTs that engaged with this intervention indicated that they value the importance of designing pedagogy to support diverse learners due to their belief that it can support achievement in science for all students. However,
after participating in a field experience, these pre-service science teachers diverge into two groups. One group of PSSTs observed an increase in perceived achievement for their students after designing their pedagogy to support diverse learners. Reasons for success included reflecting upon their unsuccessful lessons to identify what went wrong, becoming adaptive to the needs of their students, and attributing the lack of student success to themselves or the pedagogy as the agent rather than the student. A second group of PSSTs, in contrast, found no change in perceived student achievement after developing and enacting their pedagogy to support diverse learners. These PSSTs experienced difficulty due to their belief that some science content can only be taught one way, resistance by their students to participate within their lesson, and using repetition as a form of modified pedagogy.

Pre-service science teachers acknowledge that understanding the culture of students within science classrooms is necessary in order to build a rapport and engage students in learning science content. After working with secondary school students, these PSSTs diverge into two groups. The first group showed a positive view towards culture and how it impacts science instruction. These views included a consideration for the difficult home lives of their students, and making extra effort to engage disinterested students in their classroom by adapting their instruction to the needs of these students. The second group of PSSTs, however, focused on the negative aspects of diversity. This included a naive view of defining culture and how it impacts science instruction, and focusing on the negative behavioral aspects of cultural differences without attempting to discover the root cause for these behaviors.
In the next chapter, a more detailed discussion of these results is provided. This includes implications for these findings and how they connect to Ladson-Billings’ framework (Ladson-Billings, 1995), alongside other educational research on culturally relevant pedagogy.
Chapter 5 – Conclusion

My findings from this study indicate that pre-service science teachers (PSSTs) acknowledge students’ cultural understandings as an influence in learning science. PSSTs that participated in this intervention developed pedagogy based on Ladson-Billings’ (1995) foundations of culturally relevant pedagogy (CRP) in their efforts to support their students’ cultural understandings. PSSTs believe CRP can help build a rapport with students, engage students in learning science, and support achievement in science for all students. After participating in a field experience based within local school districts, I found PSSTs were successful in supporting student achievement when using the following strategies: reflecting upon unsuccessful lessons to identify what went wrong; adapting instruction to engage disinterested students; attributing the lack of student success to themselves or the pedagogy as the agent rather than the student; and considering the difficult home lives of their students. However, I also identified specific barriers that were a hindrance to PSSTs supporting student success. These barriers included: believing that some science content can only be taught one way; encountering student resistance to participate during a science lesson; using repetition as a form of modified pedagogy; possessing a naive view of defining culture and how it impacts science instruction; and focusing on the negative behavioral aspects of cultural differences without attempting to discover the root cause for these behaviors.

Within this chapter, I discuss the implications for these research findings. In particular, I discuss the effectiveness of this intervention program for supporting PSSTs in developing CRP without access to culturally diverse settings. I highlight the
successes of this intervention while also detailing specific areas that could be improved upon. In addition, I discuss the generalizability of these results and its relevance to science education research. Limitations of this research study are also discussed. Finally, future directions for this research are suggested.

**Discussion of the Intervention Program**

My study was based on an intervention program designed to support pre-service science teachers in developing culturally relevant pedagogy. The PSSTs were unable to learn about CRP through immersion into diverse classrooms, but rather the intervention provided a near-authentic experience based on the field placements available for the PSSTs. My analysis found the intervention program was partially successful in supporting PSSTs with the development of CRP. These successes show that PSSTs can begin to learn about CRP without immersing themselves into diverse classrooms. This implies that teacher certification programs with limited access to culturally diverse setting can prepare their PSSTs for some aspects of teaching within these classrooms. Immersion programs, however, seem to be necessary to fully support PSSTs with developing CRP (Bianchini & Brenner, 2010; G. Ladson-Billings, 2001). While I continue to view immersion programs as an effective means of supporting the development of CRP, my findings show that efforts can be made by teacher educators to work with PSSTs in successfully developing CRP.

Ladson-Billings’ (2001) framework for culturally relevant pedagogy identifies three criteria: indicators of academic achievement; indicators of cultural
competence; and indicators of sociopolitical consciousness. Within this section, I discuss how my findings connect to Ladson-Billings’ criteria and the potential impact of the intervention on PSSTs’ development of CRP. My discussion focuses on specific aspects of Ladson-Billings’ criteria that connect to my research findings. My findings could not connect to certain aspects, such as “has an investment in the public good,” due to the type of data I collected and the limitations of this study.

<table>
<thead>
<tr>
<th>Indicators of Academic Achievement, the teacher...</th>
<th>Cultural Competence occurs in classrooms where the teacher...</th>
<th>Indicators of Sociopolitical Consciousness, the teacher...</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.1 - Presumes that all students are capable of being educated</td>
<td>2.1 – Understands Culture and its role in education</td>
<td>3.1 – Knows the larger sociopolitical context of the school-community-nation-world</td>
</tr>
<tr>
<td>1.2 - Clearly delineates what achievement means in the context of the classroom</td>
<td>2.2 – Takes responsibility for learning about students’ culture and community</td>
<td>3.2 – Has an investment in the public good</td>
</tr>
<tr>
<td>1.3 - Knows the content, the learner, and how to teach content to the learner</td>
<td>2.3 – Uses student culture as a basis for learning</td>
<td>3.3 – Plans and implements academic experiences that connect students to the larger social context</td>
</tr>
<tr>
<td>1.4 - Supports a critical consciousness toward the curriculum</td>
<td>2.4 – Promotes a flexible use of students’ local and global culture</td>
<td>3.4 – Believes that students’ success has consequences for his or her quality of life</td>
</tr>
</tbody>
</table>

Culturally relevant pedagogy requires teachers “presume that all students are capable of being educated” (G. Ladson-Billings, 2001, p 88). Prior to their field experience, pre-service science teachers tended to hold this presumption. My findings suggest this presumption was a prior held belief of the PSSTs that was...
strengthened through their participation in the intervention. By forming a community of learners through the use of class discussions and blogs, along with the support of their mentor teachers, some PSSTs were able to develop strategies that built upon their presumption that all students can achieve academically. For example, some PSSTs considered the difficult home lives of their students and subsequently provided additional support. Considering the difficult home lives of students is not an instructional strategy per se, but rather identifies the PSSTs’ frame of mind which lead to the development of successful instructional strategies. My findings suggest that providing PSSTs with support structures such as discussion blogs during their fieldwork is helpful for the development of CRP. Other researchers (e.g. (G. Ladson-Billings, 2001) identified the importance of providing support during fieldwork and even into the first few years of practice as novice teachers can feel overwhelmed with the responsibility of teaching culturally diverse students.

Culturally relevant pedagogy also requires teachers “support a critical consciousness toward the curriculum” and “encourage academic achievement as a complex conception not amenable to a single, static measurement” (G. Ladson-Billings, 2001, p 90). My findings imply that strategies employed early during the intervention were useful in providing a gateway into these more sophisticated CRP strategies. By using familiar scenarios that focus on diversity in student learning, PSSTs can begin to identify how strategies that support diverse learners might be able to support diverse cultures. Two of these strategies, reflection and adaptation, were useful in developing aspects of culturally relevant pedagogy. Reflection and
adaptation have previously been identified as helpful tools to use within any science classroom (e.g. [Baird, Fensham, Gunstone, & White, 1991; Howard, 2003; Vazquez-Bernal, Mellado, Jimenez-Perez, & Lenero, 2012]). However, my findings suggest that reflection and adaptation become essential within culturally diverse classrooms as these tools help identify the cultural understandings of every student. These PSSTs overcame challenges that were similar to the challenges of teaching within culturally diverse classrooms (i.e. disinterested students, instructional methods unsuccessful) (G. Ladson-Billings, 2001). Reflection and adaptation were both identified as specific tools that were useful in overcoming these challenges.

While statements given by PSSTs suggest they initially presume all students can achieve academically, the actions taken by the negative experience group of PSSTs tend to contradict these previous statements. This intervention helped PSSTs begin to develop the skills necessary for developing CRP; however, the positive attitudes of these PSSTs during the intervention were not always reflected in their daily practices. For example, PSSTs indicated that they needed to support all of their students but the challenges of their field experience forced some PSSTs to abandon their efforts at engaging disinterested students. This poses a particular problem for science teacher educators, as teacher educators cannot rely solely on the attitudes of PSSTs within coursework but must also consider how those attitudes are integrated into their authentic practices. The evidence for PSST success needs to be connected to their practices within authentic settings. To be clear, I mention this issue not to portray a negative view of science teacher education. To the contrary, many PSSTs exhibit the qualities needed to become highly successful at developing CRP (e.g.
considering the difficult home lives of students, focusing on themselves or the pedagogy as the agent instead of the student). Instead, I wish to caution those that are teacher educators to continually observe PSSTs throughout their fieldwork and, if possible, into their first few years of teaching.

Culturally relevant pedagogy requires teachers “understand culture and its role in education” and “take responsibility for learning about students’ culture and community” (G. Ladson-Billings, 2001, p 115). Pre-service science teachers tend to view culture’s role in science education as a way to build a rapport and connect to the interests of their students. While PSSTs’ experiences were isolated from culturally diverse settings, my findings suggest this intervention was partially successful in supporting the ability of PSSTs to succeed within diverse classrooms. The tendency of PSSTs to acknowledge culture as an influence on learning science, combined with the observed ability of PSSTs to reflect and adapt on their own practices to support student achievement, implies PSSTs would be successful teaching culturally diverse students.

One limiting factor to consider was the lack of culture shock experienced by the PSSTs during the intervention. While the PSSTs were exposed to many different strategies intended to support CRP, there was little to no conflict that challenged their existing beliefs about teaching science within diverse cultural settings. In order to support change and have PSSTs diverge from traditional methods of teaching, or even from simply mimicking the way they were taught, PSSTs need to face scenarios where their methods of teaching are unsuccessful and given support to adapt their methods.
The focus by some PSSTs on the negative aspects of student behavior was a disappointing result. It is unlikely that these students were disinterested due to cultural differences with the PSSTs as field experiences were not in culturally diverse settings. However, this result implies these PSSTs will have difficulties in culturally diverse settings as cultural differences between teacher and student may manifest as disinterest in science. While the intervention provided PSSTs with strategies to handle student disinterest in science, there were multiple instances of these PSSTs blaming the student for this lack of interest. Mentor teacher attitudes were found to have a large influence on PSSTs attitudes towards these students. When mentor teachers made negative statements that indicated some students would not succeed, many PSSTs adopted this attitude within the classroom. These findings indicate that efforts to support PSSTs in developing CRP needs to expanded into field experiences.

Limitations of the Study

While every effort was made to minimize potential biases, some limitations exist within this research study. In order to present these results, it is important to identify these limitations as influencing factors on my analysis. These limitations included the lack of data collected from culturally diverse science classrooms, the limited number of participants, and that the researcher was also the primary instructor for this methods course and thus a form of self-study.

The first limitation to this research study was that it was entirely conducted without data being collected from culturally diverse science classrooms. While I
would have preferred to investigate how successful the intervention was to support PSSTs in culturally diverse science classrooms, the very nature of this study limited access to these settings. However, I stress that the attitudes shown by the PSSTs within the positive results group are indicative of culturally relevant practices, and that these attitudes will support these PSSTs if they teach within culturally diverse settings. Nevertheless, it is important for me to acknowledge this limitation of my analysis as it does limit the impact of my results.

The second limitation to this study was the limited number of participants within this research study. This research study was conducted over the course of a single semester, with fifteen (15) participants taking part within this study. A larger number of participants, alongside multiple iterations of this research study, would have been preferred in order to better inform and strengthen the results of my analysis.

The third limitation to this study was that portions of data collected included PSSTs self-reported experiences during their field experience. Discussion blog entries may have been influenced by PSSTs hesitant to share challenging experiences for fear of appearing incompetent or receiving a poor grade for their methods class. While this limitation unlikely affected result obtained from the negative experience group, this could have potentially influenced results obtained from the positive experience group.

The fourth and final limitation to this study was that the researcher was also the primary instructor for this methods course. While I made multiple attempts to limit any undue influence, I acknowledge that my role as primary instructor may
have unintentionally biased my analysis. For example, responses given by these PSSTs may have been to perform well within this methods course (i.e. getting a good grade versus making an honest statement). To minimize this bias, I performed a thorough analysis of my data, which included identifying the statements of PSSTs to determine whether it was an isolated incident, which would indicate a biased response.

While these limitations were a part of this research study, all methodological approaches have limitations. I identify these limitations not as a way reduce the relevance or power of these findings and their potential impact on science education research, but rather to become transparent with the reader so that he or she can determine the transferability of these results to his or her own research studies.

**Future Directions for this Research**

Results from this research study present many more opportunities for further research into how to support PSSTs in developing CRP. While portions of this intervention program were successful, results from the negative experience group could be used to modify and improve the intervention program. For example, one of the barriers to developing CRP was that some PSSTs tended to focus on the negative behavioral aspects of culture without determining the root cause for these behaviors. Future iterations of this intervention program would work towards challenging PSSTs in classroom management scenarios. Some PSSTs became frustrated when they encountered student resistance to instruction; additional discussions of classroom management scenarios could potential ease this
frustration. In addition, the intervention program should be expanded to include a support structure for PSSTs during their field experience. While my findings suggest discussion blogs are an effective means of supporting PSSTs, additional support structures should be integrated into the intervention program. Site visits would help identify specific challenges faced by the PSSTs, and methods instructors could provide one-on-one assistance to help overcome these challenges.

Another modification to the intervention program includes forming partnerships with science educators teaching within culturally diverse school districts. While this teacher certification program was geographically isolated from culturally diverse settings, video conferencing would allow opportunities for PSSTs to observe and remotely teach within culturally diverse classrooms.

One final modification to the intervention program includes collaborating with other courses taught at the university. Many universities offer courses specifically designed to help students understand culture and its role in education. Pairing science methods coursework with these courses on cultural understanding would provide additional opportunities to learn about culturally relevant pedagogy. Science methods courses may be limited on the amount of time spent discussing CRP; partnering with courses that focus on understanding culture would increase the amount of time available to discuss these issues.

This research study primarily collected data within a second semester science methods course, with some data taken during the PSSTs’ field experience. The next step for this research project would include following PSSTs that participated in this intervention into their first year of teaching. Of particular
interest would be those PSSTs that begin their careers teaching at culturally diverse school districts. Investigating these PSSTs into their first year of teaching would help further determine the success of this intervention and identify areas in which the intervention could be improved upon.

Finally, I suggest that other researchers should investigate the feasibility of intervention programs designed to support the development of CRP. Previous studies on the development of CRP tend to focus primarily on immersion aspects (Bianchini & Brenner, 2010; G. Ladson-Billings, 2001; G. J. Ladson-Billings, 1999; Luft, Bragg, & Peters, 1999). Future research should expand into investigating certification programs that have limited access to culturally diverse settings.

**Conclusion**

Science teachers need to be able to support all students in learning science. Cultural differences between teacher and student can become barriers to proper science instruction. Culturally relevant pedagogy is an essential tool that science teachers can use to support achievement for all students. Teacher certification programs have a responsibility to prepare their candidates for the challenges of teaching within culturally diverse classrooms.

This study shows promise for pre-service science teachers being able to develop culturally relevant pedagogy. Teacher certification programs that have limited access to culturally diverse settings can do some work to prepare their PSSTs for teaching within these classrooms. Support structures during fieldwork, such as using discussion blogs, can support novice teachers experiencing difficulties
within culturally diverse classrooms. In addition, reflection and adaptation were identified as potential tools that support the development of CRP. However, there are indications of barriers that pose difficulties for PSSTs becoming proficient at CRP. These barriers are: (1) a tendency to make pedagogical choices based primarily on personal experiences learning science and observing professionals within school settings; (2) a disconnect between the espoused values of pre-service science teachers and evidence of these values being integrated into their practices; and (3) a naïve view of defining culture and how it impacts science instruction.

Finally, it should be stressed that this intervention is in no way intended to be an adequate substitution for immersion programs. Providing pre-service science teachers with experience in diverse classrooms is important to support them learning how to teach science to diverse populations. However, these experiences are difficult to provide when universities are isolated from culturally diverse settings. In addition, pairing immersion programs with this intervention could be a benefit for the development of CRP. Interventions that support the development of CRP need to be integrated into the certification programs of isolated universities so that we can train all PSSTs to become successful within culturally diverse classrooms.
List of References


Vygotsky, L. S. (1978). Mastery of Memory and Thinking


Appendix: Interview Protocol

Interview Script: (Pre-)

Note: This is a general template for interview questions. If the subject says something surprising or interesting that is relevant to the study, probing questions can be added to the interview.

1) Notice that this study is being conducted solely for research purposes and is affiliated with Penn State University.

2) Assure the subject that this interview will be kept confidential until the end of the semester, at which point the recordings will only be shared amongst the research personnel.

3) Go over the main purpose of the interview; that is, to investigate initial conceptions of social and cultural influences in science and science education. There are no right or wrong answers in this interview, only your impressions.

4) Just to begin, I’d like to get to know a little more about your background. Can you tell me…
   a. About the area you grew up in? Was it a rural, urban, or suburban area?
   b. Would you say that your K-12 classes had a diverse population of students (Try to gauge how the interviewee defines diverse, ask for more information if necessary)?
   c. How much experience, prior to this class (SCIED 412), have you had working with children?

5) Now, I’d like to know a little more about your career plans. Can you tell me…
   a. Are you an undergraduate or a graduate student?
   b. What do you plan to do after graduation?
   c. What subject matter, or subject matters, would you like to teach?
d. Are there any specific school districts or locations you’d like to teach at? What type of school district are you hoping to teach at: rural, suburban, or urban, or do you have a preference?

6) Can you tell me a little bit...
   a. ...about your experiences in science classes throughout your middle and high school careers?
   b. Do you feel that you were well prepared for college science classes?
   c. What types of qualities would you define as “good science teaching?”

7) A lot of teacher educators believe that the cultural backgrounds of students is important to consider in science education.
   a. What do you think the term “cultural background” means?
   b. If you were asked to teach a class of diverse populations, what do you think that classroom would look like?
   c. How do you think the cultural backgrounds of students play a role in the science classroom? Can it help or hinder learning?
   d. How might teachers adapt their instruction to include all students in the learning process? (Probing question additions: how it may help or hinder learning on the part of the student, how teachers might cope with multicultural settings, is science curriculum biased, etc.)

8) Let’s say you were asked to teach in a classroom from a social environment different from your own. This could be an urban classroom, a rural classroom, perhaps teaching African American students, Native Americans students, students from a culture significantly different from your own.
   a. Would you modify your science teaching at all within these settings? If so, how? If not, why not?
Interview Script: (Post-)

Note: This is a general template for interview questions. If the subject says something surprising or interesting that is relevant to the study, probing questions can be added to the interview.

1) General introductions (introduce yourself, ask for subject’s name, year in program, science content area, plans for post-graduation)

2) Notice that this study is being conducted solely for research purposes and is affiliated with Penn State University.

3) Assure the subject that this interview will be kept confidential until the end of the semester, at which point the recordings will only be shared amongst the research personnel.

4) Go over the main purpose of the interview; that is, to gain a better understanding of how you viewed the activities from the previous week and your experiences with the teaching clinics.

5) During this semester, we’ve talked a lot about how to teach to a culturally diverse or dissimilar classroom. Can you discuss some of these ideas? Do you feel these would be effective? Why or why not?

6) Do you feel that instruction in science depends on the culture of the students, or do you feel that science instruction is universal and is easily accessible to all? (A universal standpoint may make the rest of these questions moot: try to probe the understanding of why the interviewee adopts a universal attitude to instruction, make sure it is clear, then end the interview)

7) One of the issues that science teachers must deal with is that it is difficult to teach science content effectively without being familiar with the culture of their students. With the exception of being provided with authentic experiences within these cultures, how might science teachers be better prepared before stepping foot within these classrooms? Or, do you feel that it is not at all possible to prepare teachers without some experience dealing with diverse or dissimilar cultures?
8) Let’s say you were hired to teach at a school district that has a culturally diverse or dissimilar student population to what you’re used to. How would you approach this classroom? If you were asked to create an entire unit plan before even meeting the students, what ideas would you want to keep in mind to best instruct these students?

9) I’d like to ask about specific populations and how you may (or may not) change instruction to better suit the needs of these students. So tell me a topic within your certification area and a lesson you are quite comfortable with teaching. What would your lesson look like if you were asked to teach within:

   a. A school district similar to your own high school experience
   b. An entirely female classroom
   c. An inner-city school district
   d. An international school where English is the second language
   e. A school district located within a Native American Reservation
Curriculum Vitae

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Education:
- Slippery Rock University of Pennsylvania
  Bachelor of Science in Physics, Minor in Mathematics (May 2002)
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- Slippery Rock University of Pennsylvania
  Masters of Education in Secondary Education Certification in Physics and Math (May 2005)
  Overall GPA: 3.750/4.000
- Pennsylvania State University
  Doctor of Philosophy in Curriculum and Instruction (December 2014)
  Overall GPA: 3.840/4.000
  Dissertation Focus: Pre-Service Science Teacher Education, Culturally Relevant Pedagogy

Employment History:

Instructor, Biology and Science Education, Edgewood College (August 2014 – Present)
- "Introduction to Natural Science for Elementary Education I (NATS 104S) and II (NATS 105S)"
- "Methods: Science and Environmental Education I (ED 427A) and II (ED 427A W)"

Science Education Instructor, Science Education, Pennsylvania State University (August 2009 – May 2014)
- Teaching Secondary Science I (SCIED 411) and II (SCIED 412), required for pre-service science teachers
- Teaching assistant (Fall 2009, Spring 2010, Fall 2011) and Instructor in Charge (Fall 2010, Spring 2011, Spring 2012, Fall 2012)
- Teaching Secondary Science I (SCIED 411) is an introductory course for individuals planning to teach in grades 7-12. This class helps students forge a 'philosophy of science teaching' that is supported by research based findings on learning, scientific inquiry, and the effective design of lessons and activities.
- Teaching Secondary Science II (SCIED 412) is a second semester course that builds upon core values developed within 411. While the focus of 411 is based on introducing the foundations of science teaching, this course expands upon these foundations and supports pre-service science teachers in developing unit plans built upon big ideas and storylines, peer-teaching activities that promote self-reflection from video analysis, and classroom discussions on topics such as supporting diverse populations, effective assessment strategies, and classroom management techniques.

Science Education Lab Manager, Science Education, Pennsylvania State University (August 2008 – May 2014)
- Supervised work-study students who assisted with the day-to-day responsibilities of the lab. This included providing students and faculty with requested materials, organizing science education classrooms and lab supply rooms, and maintaining an online inventory of available SCIED Lab materials.
- Highly experienced in the use of educational technology. Supported faculty in students in using PASCO probes, digital microscopes, digital cameras, and OS software.

- Only Full-Time Physics teacher at the high school. In addition to my general teaching responsibilities, I set up informal learning activities for the students (e.g. Physics Day at Hershey Park), proposed and developed new curriculum to the UDA School Board, and became highly involved in the needs of the community and the personal interests of my students (e.g. attended multiple student sporting events, announcer and coach for extracurricular events, chartered student dances and events).
- Courses taught included: Conceptual Physics, College Prep Physics, and Honors Physics intended for juniors and seniors; General Science intended for sophomore students in preparation for PSSA testing; and Science, Technology and Society, an environmental science course, intended for juniors and seniors.
- Supervisor for Student Council, Rocketry club, and Drama club

Assistant to the Physics Department, Physics, Slippery Rock University (May 2004 – December 2004)
- Graded lab assignments and homework for Concepts of Science I (64-101) and Elements of Physics I (64-201)
- Assisted professors in setting up labs and taking inventory of the entire Physics department over the summer