The Effects of Community-Based Service-Learning on Preservice Elementary Teachers’ Self-Efficacy Beliefs about Equitable Science Teaching and Learning

by

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# TABLE OF CONTENTS

LIST OF TABLES ............................................................................................................. iv

LIST OF FIGURES ............................................................................................................ v

ABSTRACT ....................................................................................................................... vi

CHAPTER ONE: THE PROBLEM .................................................................................. 1
   Introduction ............................................................................................................. 1
   Self-Efficacy Beliefs ............................................................................................... 3
      Science Teaching Efficacy ................................................................................. 4
      Science Teaching Efficacy and Diversity ......................................................... 7
      Developing Science Teaching Efficacy ............................................................. 9
   Service-Learning and Multicultural Science Teaching ........................................ 11
   Problem Statement ............................................................................................... 14
   Research Questions ............................................................................................... 15
      Question 1 ................................................................................................. 15
         Rationale ............................................................................................... 15
      Question 2 ................................................................................................. 15
         Rationale ............................................................................................... 16
      Question 3 ................................................................................................. 16
         Rationale ............................................................................................... 16
      Question 4 ................................................................................................. 17
         Rationale ............................................................................................... 17
   Significance of Study ............................................................................................. 18
   Definition of Terms ............................................................................................... 21

CHAPTER TWO: LITERATURE REVIEW .................................................................. 22
   Introduction ......................................................................................................... 22
   Science Education Reform ................................................................................... 25
   Science Teacher Education Reform ..................................................................... 28
   Educational Equity ............................................................................................... 30
   Equity and Science Education ............................................................................ 31
   Demographic Divide ............................................................................................. 36
   Teacher Beliefs ..................................................................................................... 41
      Teacher beliefs and urban students ................................................................. 48
   Effective Teachers of Diverse Students ............................................................... 55
   Self-Efficacy Beliefs ............................................................................................. 60
      Attitudes ......................................................................................................... 60
CHAPTER THREE: METHODOLOGY ........................................ 83
  Introduction............................................................................... 83
  Research Questions..................................................................... 87
  Research Design ........................................................................ 87
    Target Population and Sampling ........................................... 88
    Context of Study .................................................................... 92
      The University ................................................................. 92
      Methods Courses ............................................................ 92
        Section 1 ..................................................................... 93
        Section 2 ..................................................................... 96
        Section 3 ..................................................................... 98
      The Instructors .................................................................... 100
        Instructor Roberts ......................................................... 100
        Instructor Edwards ....................................................... 101
      University Area Community ............................................ 105
        Community Center/Elementary Students ...................... 106
  Instrumentation ....................................................................... 108
    Quantitative Methods.......................................................... 108
      Quantitative Instruments ................................................ 108
      Reliability and Construct Validity .................................... 109
      Data Collection ................................................................ 110
        Test Reliability ............................................................ 111
      Data Analysis ................................................................... 111
    Qualitative Methods........................................................... 112
      Researcher bias ............................................................... 112
      Qualitative Instruments .................................................. 113
        Semi-Structured Interviews ......................................... 115
        Interviewer .................................................................. 116
        Pre-Post Questionnaires .............................................. 118
        Passive Observation .................................................... 119
      Data Collection ................................................................ 119
        Pilot Study .................................................................. 119
        Research Study ............................................................ 121
      Data Analysis ................................................................... 122
        Inter-rater Agreement .................................................. 123
        Trustworthiness ............................................................ 124
  Summary ................................................................................. 127

ii
LIST OF TABLES

Table 1. Demographics of Participants................................................................. 89
Table 2. Interview Participant Characteristics..................................................... 91
Table 3. General Overview of Instructors............................................................ 105
Table 4. Sample Interview Questions addressing Study’s Inquiry....................... 116
Table 5. Qualities of a Skilled Interviewer.......................................................... 118
Table 6. Effective Science Teacher Characteristics............................................. 132
Table 7. 3 x 2 Factorial Repeated-Measures ANOVA for SEBEST PSTE Scores .... 144
Table 8. Mean PSTE Scores and STOE Scores on SEBEST ................................... 144
Table 9. 3 x 2 Factorial Repeated-Measures ANOVA for SEBEST STOE Scores ..... 146
Table 10. Science Methods Course Experience Means......................................... 148
Table 11. Multicultural Pedagogical Beliefs......................................................... 170
Table 12. Limiting Pedagogical Beliefs............................................................... 178
LIST OF FIGURES

Figure 1. Conceptual Framework for a Study of Beliefs and Equitable Science Teaching and Learning ...... 20

Figure 2. Average scale score for grade 4, Race/ethnicity ............................................... 34

Figure 3: Changing Demographics for Students of Color ................................................ 38

Figure 4. Current and Future Teacher Population ................................................................. 39

Figure 5. The cyclical nature of teacher efficacy ................................................................. 67

Figure 6. Factors affecting Science Teaching Efficacy ......................................................... 81

Figure 7. Main Study Features ................................................................................................ 85

Figure 8. Beliefs about Multicultural Science Teaching ....................................................... 155
The effects of community-based service-learning on preservice elementary teachers’ self-efficacy beliefs about equitable science teaching and learning

Neporcha Cone

ABSTRACT

The *National Science Education Standards* (NRC, 1996) and *Science for all Americans* (AAAS, 1989) explicitly state that *all* students regardless of their age, cultural or ethnic backgrounds, gender, abilities, aspirations, or interest in science should have access to equitable educational resources in science. These equitable resources also include access to efficacious teachers of *all* students. However, the *Standards* fail to explicate what practices, if any, lead to the development of these teachers. The primary purpose of this study was to identify teacher education practices that positively influenced preservice elementary teachers’ self-efficacy beliefs about equitable science teaching and learning. More specifically, this research study explored the effects of community-based service-learning on the self-efficacy and pedagogical beliefs of preservice elementary teachers regarding equitable science teaching and learning.

This study utilized a mixed-methods research design. Data were collected from 67 participants registered in three elementary science methods courses. One of the science methods courses had an embedded service-learning component. Semi-structured interviews and questionnaires were used to analyze teacher beliefs, attitudes, and sources of self-efficacy. A quasi-experimental design was used to quantitatively measure
changes in science teacher efficacy beliefs in regard to equitable science teaching and learning. Changes in participants’ scores were analyzed using two 3 x 2 Factorial Repeated-Measures ANOVAs. The results of this study support the value of preservice teachers engaging in community-based service-learning experiences as a way to improve their self-efficacy beliefs and pedagogical beliefs regarding equitable science teaching and learning.
CHAPTER ONE: THE PROBLEM

Introduction

As the educational landscape continues to become increasingly diverse, the critical role of teachers’ beliefs and self-efficacy in promoting an equitable learning environment is becoming more apparent. Convincing research suggests that the beliefs preservice elementary teachers possess about their ability to teach science play a vital role in shaping their teaching practices (Bandura, 1997; Enochs & Riggs, 1990; Tschannen-Moran, Woolfolk Hoy, & Hoy, 1998). Yet, despite the number of science classes taken, preservice teachers continue to enter their student teaching semesters, and professional careers, unconfident in their ability to teach science (Fulp, 2002; Tosun, 2000; Weiss, 1997). Specifically, less than a third of elementary teachers feel prepared to teach science (Fulp, 2002; Weiss, 1997).

Equally important is the fact that many preservice teachers, the majority of whom have different sociocultural backgrounds from their future students (Hodgkinson, 2002; Nieto, 2002), continue to matriculate through their teacher education programs with preconceived beliefs about diversity that may lead to conflicts in cultural values, miscommunication, low teacher expectations, ineffective instructional practices and consequently low student achievement (Banks, 2001; Cochran-Smith, 1995, 2000; Delpit, 1995; Gomez & Tabachnick, 1992; Stegemiller, 1989; Tilgner, 1990). These beliefs
coupled with preservice teachers’ low self-efficacy may limit equitable science teaching and learning opportunities for diverse student groups.

Preparing preservice teachers for the diversity they will encounter in science classrooms necessitates a closer look at strategies for improving preservice teachers’ beliefs about their ability to be effective teachers of diverse student groups. Consequently, current science education reform initiatives have focused on improving preservice teacher education (National Research Council, 1996; National Science Teacher Association, 2003). With the inclusion of chapters titled “Standards for Professional Development for Teachers of Science” and “Teacher Education,” the National Science Education Standards (NSES) and Blueprints for Reform: Science, Mathematics, and Technology Education, respectively, have explicitly made science teacher education an essential component of science education reform (AAAS, 1998; NRC, 1996). Raizen and Michelson (1994) underscore the importance of preparing preservice elementary teachers to teach science by stating, “the science education of preservice elementary school teachers is seen as a critical component in the systemic approach necessary to make real and lasting change in a classroom reality” (p. 7). Therefore, answers to the following question may be of considerable interest to the scientific community: What teacher education practices, if any, positively influence preservice elementary teachers’ self-efficacy beliefs about equitable science teaching and learning?

Research studies have documented the positive effects of field experiences on teacher self-efficacy (Wade, 1995; Woolfolk Hoy & Burke Spero, 2005). In addition, field experiences, such as service-learning in urban areas, have been shown to challenge
preconceived beliefs about diversity and help preservice teachers understand the educational concerns of diverse student populations (Boyle-Baise, 2002; Wade, 1995, 2000). Thus, researching the relationship between community-based service-learning and science teacher efficacy beliefs may provide a first step toward answering the aforementioned question. This study explored the effects of community-based service-learning on the self-efficacy beliefs of preservice elementary teachers regarding equitable science teaching and learning. The remainder of the chapter will introduce the theoretical framework of self-efficacy beliefs, which is central to the research. This chapter will conclude with a discussion of the study’s significance for science education researchers and practitioners.

Self-Efficacy Beliefs

If an individual wants to alter his or her thinking and behavior, Bandura (1986, 1997) argues that one must be able to reflect and evaluate his or her own actions. This self-evaluation includes evaluating one’s sense of self-efficacy. He describes self-efficacy as “beliefs in one’s capabilities to organize and execute the courses of action required to manage prospective situations” (p. 389). Bandura (1977, 1997) divided the construct of self-efficacy into two cognitive domains: personal efficacy and outcome expectancy. He asserts that when compared to different features of self-knowledge, personal efficacy is the most influential aspect in the everyday lives of people.

Personal efficacy is defined as “judgments about how well one can organize and execute courses of action required to deal with prospective situations that contain ambiguous, unpredictable, and often stressful elements” (Bandura, 1977, p. 201). Outcome expectancy is explained as “a person’s estimate that a given behavior will lead
to certain outcomes” (p. 201). Personal efficacy and outcome expectancy beliefs have been differentiated due to the fact that one can believe that a particular action will produce certain outcomes, yet not believe that implementing this action will influence an individual’s behavior (e.g. student motivation, achievement, behavior, etc.).

Bandura (1977, 1997) also noted that those individuals who possess a low sense of self-efficacy have low aspirations, weak commitments to goals, dwell on personal deficiencies, and shy away from difficult tasks. Conversely, those who possess a high sense of self-efficacy set challenging goals while maintaining a strong commitment to them, face failures and setbacks by redefining their effort, and approach challenging tasks as assignments to be conquered rather than as threats to be avoided. Enochs and Riggs (1990) extended this idea to science teaching noting that the extent to which teachers believed they can influence student learning was important for effective science teaching. In other words, those teachers with a high sense of self-efficacy were more likely to be effective science teachers, while those who possessed a low sense of self-efficacy were more likely to be ineffective science teachers.

### Science Teaching Efficacy

Research studies suggest that elementary teachers do not care to teach science, stay away from science, and are not confident in their ability to teach science (Czerniak & Chiarlott, 1990; Shrigley, 1974; Tilgner, 1990; Weiss, 1997; Weiss, Matti, & Smith, 1994). Koballa and Crawley (1985) reported, “A teacher’s attitude toward science is reflected in the time the teacher spends teaching science and in the manner in which it is taught” (p. 228). They also noted that these attitudes were buttressed by low self-efficacy
beliefs. As a result, low self-efficacy beliefs may lead to the conceptualization and implementation of poorly designed science curricula by preservice elementary teachers.

Scaffolding off of Bandura’s theory of self-efficacy and Gibson and Dembo’s Teacher Efficacy Scale (Gibson & Dembo, 1984), Enochs and Riggs (1990) extended the theory of self-efficacy and its cognitive constructs, personal teaching efficacy and outcome expectancy, to the study of science teaching. They created the Science Teaching Efficacy Beliefs Instrument (STEBI) Form A for inservice teachers and Form B for preservice elementary teachers. Both instruments consist of 23 statements with 5-point Likert-scaled items. Enochs and Riggs (1990) predicted that teachers who believed that student learning could be influenced by effective teaching (i.e. those with high Science Teaching Outcome Expectancy (STOE) scores) and were confident in their own teaching abilities (i.e. those with high Personal Science Teaching Efficacy (PSTE) scores) would persist longer. In addition, as opposed to teachers who exhibited low science teaching efficacy, these teachers would be able to provide increased academic focus in the classroom and exhibit a repertoire of ideas and strategies. Similarly, Czerniak (1990, as cited in Plourde, 2002) noted that highly efficacious teachers were more likely to implement inquiry-based activities in the science classroom, while those teachers who possessed a low sense of self-efficacy were more likely to focus on teacher-centered activities.

Multicultural educators contend that efficacious science teachers are also multicultural science teachers. They are knowledgeable about science content (Atwater, 1993) and are self-confident (Zeichner, 1993). They possess strong communication skills and are able to connect science to students’ lived experiences (Atwater, 2000). They hold
themselves and their students to high expectations (Zeichner, 1993), regardless of their students’ sociocultural backgrounds (Atwater, 2000; Ladson-Billings, 1994). They use didactic instructional practices, along with traditional and alternative forms of assessment (Fradd & Lee, 1999; Zeichner, 1993). They are creative and encourage students to actively participate in the construction of scientific knowledge (NRC, 1996). They are skillful in their use of questioning and create environments that foster the development of critical and creative thinking skills in the science classroom (Zeichner, 1993).

Efficacious teachers of diverse students are empathetic (Ladson-Billings, 1994; Zeichner, 1993). This empathy is shown when teachers acknowledge and validate the different ways of knowing and learning diverse students bring to the science classroom (Atwater, 2000; Lee, 1999). Finally, effective teachers are reflective practitioners. They are able to reflect on their practice, learn from their experiences, and modify their instruction to meet the needs of all students (NRC, 1996; Rodriguez, 1998b).

Preservice elementary teachers enter science methods courses with preconceived beliefs about their ability to be effective science teachers. These beliefs have been filtered by a lifetime of personal experiences and will strongly influence how they teach (Czerniak & Chiarlott, 1990, Yerrick & Hoving, 2003), whom they teach (Boyles-Baise, 1998), and how they learn (Riggs, 1991). Since many teachers aspire to be effective science teachers, and these aspirations underpin self-efficacy beliefs (Bandura, 1997), it is important to understand these beliefs 1) if all children are to become scientifically literate; and 2) to create experiences that challenge, or reaffirm, these preexisting beliefs. Thus, this study examined the characteristics preservice elementary teachers perceived as belonging to effective science teachers.
Science Teaching Efficacy and Diversity

Teacher educators and teachers face the overwhelming challenge of designing and implementing pedagogical strategies that will work in a multicultural society. To ensure equitable science teaching for diverse learners, the National Science Teacher Association (NSTA) has issued the following position statement in regard to multicultural science education:

- Schools are to provide science education programs that nurture all children academically, physically, and in the development of a positive self-concept;
- Children from all cultures are to have equitable access to quality science education experiences that enhance success and provide the knowledge and opportunities required for them to become successful participants in our democratic society;
- Curricular content must incorporate the contributions of many cultures to our knowledge of science;
- Science teachers are knowledgeable about and use culturally-related ways of learning and instructional practices;
- Science teachers have the responsibility to involve culturally-diverse children in science, technology and engineering career opportunities; and
- Instructional strategies selected for use with all children must recognize and respect differences students bring based on their culture (NSTA, 2004)

However, many researchers have documented the negative beliefs and attitudes held by teachers regarding diversity, which are incompatible with science education reform position statements. Gomez and Tabachnick (1992) found that the negative beliefs and
attitudes possessed by preservice teachers toward children of color and children from low-income backgrounds may limit equitable science teaching and learning. Similarly, Stegemiller (1989) concluded from his literature review that teacher expectations for academic success were based on attractiveness, social class, ethnicity, and possibly gender. Furthermore, Rodriguez (1998b) and Yerrick and Hoving (2003) noted the ideological and pedagogical resistance they experienced when attempting to introduce and implement multicultural science education practices with white preservice science teachers. Consequently, the success of “science for all” may depend on teachers who possess ideological and pedagogical beliefs that are consistent with reform efforts.

While self-efficacy beliefs may be influenced by the preconceived notions teachers have about their ability to be effective science teachers, they may also be influenced by the beliefs teachers possess about students’ abilities to be successful in science. For many teachers, these beliefs are based on factors such as gender, socioeconomic status, race, language, ethnicity, and culture (Atwater, 1996; Gomes & Tabachnick, 1992; Lee, 1999; Rodriguez, 1998b; Stegemiller, 1989; Yerrick & Hoving, 2003). Cognizant of the interconnectedness of science teacher efficacy beliefs and teachers’ preconceived beliefs about student diversity, Ritter, Boone, and Rubba (2001) modified the STEBI-B to include concepts related to diverse student populations.

Given that self-efficacy beliefs are valid predictors of preservice elementary teachers’ behavior regarding science teaching and learning (Bandura, 1986, 1997; Enochs & Riggs, 1990; Tschannen-Moran, et al., 1998), and their ability to implement effective science teaching practices (Enochs & Riggs, 1990), Ritter et al. (2001) developed the Self-Efficacy Beliefs about Equitable Science Teaching and Learning (SEBEST)
instrument. It measures the self-efficacy beliefs of preservice elementary teachers regarding their perceived ability to teach science effectively to diverse populations and their ability to affect student outcomes based upon their perceived ability. This study measured the effects of three science methods courses, situated in different environments, on preservice elementary teachers’ science efficacy beliefs about equitable science teaching and learning. The early detection of low-self efficacy beliefs can be a valuable tool for providing specific experiences aimed at positively influencing the self-efficacy beliefs of preservice elementary teachers as it relates to teaching science in a pluralistic environment.

Developing Science Teaching Efficacy

A teacher’s confidence in his or her ability to promote student success is a powerful force in learning and motivation. According to Bandura (1997), self-efficacy is an important predictor of one’s ability to solve ill-structured problems, master higher order thinking skills, and accomplish goals. Teaching self-efficacy has been associated with important factors such as student motivation, student achievement, innovative teaching practices, classroom management, and the amount of time spent teaching certain subjects (Bandura, 1997; Tschannen-Moran et al., 1998). Yet, what factors influence teaching self-efficacy beliefs?

Bandura (1977, 1997) postulated that there are four sources from which people collect information: enactive mastery experiences, vicarious experiences, physiological and emotional states, and social persuasion. Enactive mastery experiences are considered to be the most powerful in influencing teaching self-efficacy; that is, if an individual perceives success at accomplishing a task, he or she is more likely to
undertake that task again. However, the perception of failure tends to lower one’s sense of self-efficacy. This is particularly true when failure cannot be ascribed to lack of effort or external variables.

Bandura’s second source of self-efficacy is that of *vicarious experiences*. Learners tend to gain insight when someone else models a specific task. The degree to which the observer identifies with the model regulates the efficacy effect on that observer. Watching others succeed, whom they perceive to be of the same ability level, allows the learner to reevaluate personal expectations and his or her capabilities. If the person modeling the task performs well, the observer’s efficacy expectations may increase. However, if the person modeling the task performs poorly, the efficacy expectations of the observer may decrease.

A learner’s ability to reflect upon his or her *emotional and physiological states* also affects the development of self-efficacy beliefs. Bandura (1997) contends that the human body can inform its owner of emotions that may not be apparent on the surface. He goes on to posit that learners scrutinize self-efficacious feelings against internal arousal states (Bandura, 1986). The level of arousal influences feelings of self-efficacy. Anxiety, which may be exhibited by signs of perspiration or nausea, tends to sway an individual towards feelings of incompetence. On the other hand, excitement, which, for example, may be exhibited by a teacher who smiles a lot, may lead to feelings of confidence.

Finally, self-efficacy beliefs are influenced by *verbal persuasion*; that is, evaluative feedback given by instructors or peers. Encouraging messages help individuals to put forth the extra effort it may take to initiate a task, challenge
stereotypes, attempt new strategies, and/or succeed against perceived obstacles (Bandura, 1986). Bandura cautions that negative messages can just as easily undermine high self-efficacy beliefs, instilling self-doubt. However, the effectiveness of persuasion, whether negative or positive, depends on the credibility, trustworthiness, and expertise of the persuader (Bandura, 1986). This study sought to determine what course experiences, if any, preservice elementary teachers identify as being influential on the development of their positive attitudes towards equitable science teaching.

Service-Learning and Multicultural Science Teaching

Mastery experiences, within the context of teacher education programs, are those instances where preservice teachers are provided with opportunities to actually perform the act under question (Fives, 2003). Mastery experiences such as tutoring, microteaching, or student teaching, all have promise in enhancing science teaching efficacy (Cannon & Scharmann, 1996, Enochs & Riggs, 1990; Waters & Ginn, 2000). They can also serve as a forum for challenging preconceived beliefs about diverse populations. More specifically, field experiences such as community-based service-learning create spaces that interrupt and challenge preconceived beliefs about diversity, while allowing preservice teachers an opportunity to link academic content with community service (Boyle-Baise, 1998, 2000).

Service-learning has its roots in the early writings of John Dewey and is often linked with the early philosophical foundation of experiential education. Dewey (1938) believed that students must be allowed to think. He also believed that students must be provided with experiences that allow them to connect thinking with practice. As opposed to recognizing a collective hegemonic voice, Dewey understood that students must be
given the chance to involve themselves in the deepest problems of society. Since Dewey, community-based service-learning has been viewed as a pedagogical alternative that promotes the development of competent and effective citizens by combining academic instruction with service to the community, with a focus on critical, reflective thinking (Billig & Furco, 2002; National Service-Learning Clearinghouse, 2004).

As noted by Dewey (1966), learning requires that the learner see meaning and relevance in their experiences. Meaning and relevance will be determined by the degree to which an individual is able to make learning his or her own. The use of reflection in the service-learning context has been called the “link that ties students’ experiences in the community to academic learning” (Eyler & Giles, 1999, p. 171) and meaning-making. Infusing community-based service-learning into science teacher education programs may unmask belief systems that contribute to the difficulties experienced by preservice elementary teachers in relation to their ability to carry out effective science instruction; particularly as it relates to teaching science to diverse populations. Moreover, community-based service-learning can provide a “critical lens” for viewing issues pertaining to equity in science teaching, commonly referred to as multicultural science teaching (Atwater, 1996).

Developing positive self-efficacy beliefs in regard to multicultural science teaching requires preservice elementary teachers to 1) delineate sociocultural factors (e.g., race/ethnicity, SES, language, culture) that may act as bridges or barriers to academic success; 2) be willing and/or able to think critically about their beliefs and attitudes; and 3) adjust their ideological and pedagogical beliefs accordingly to meet the needs of an increasingly diverse student body. However, the aforementioned critical
thinking skills are not innate. Consequently, science teacher education programs must provide experiences that foster the development of these skills.

Research indicates that preservice teachers who participate in community-based service-learning change their beliefs and attitudes toward multicultural science teaching and recognize the need for multicultural science curricula (Calabrese Barton, 2000). Therefore, the aforementioned critical thinking skills may be cultivated more effectively through the use of the experiential perspective of community-based service-learning. The present study examined how the beliefs of a group of preservice elementary teachers regarding multicultural science teaching changed, if at all, as a result of their community-based service-learning experiences.
Problem Statement

Since the publication of the 1983 *A Nation at Risk Report*, demands for highly qualified teachers undergird reform documents. Systemic reform initiatives have indirectly targeted teachers’ race, cultural norms, and beliefs and attitudes toward diversity as crucial factors of students’ academic success, or lack thereof, in science education (AAAS, 1989; NCATE, 2004; NRC, 1996). Given this concern, in the context of an increasingly diverse school-aged population, there is a need to determine what teacher education practices will promote the development of efficacious teachers whose beliefs and attitudes are consistent with the call to reformation. To address this issue, many organizations have made the effective preparation of teachers an essential priority for science education reform (AAAS, 1989; NRC, 1996; NSTA, 2004). For instance, one of the National Science Teachers Association’s Standards for Science Teacher Preparation elucidates that teachers must be able to successfully promote the learning of science by students with different abilities, needs, interests, and backgrounds (NSTA, 2004).

However, the standards recommended by these organizations are entrenched in a “discourse of invisibility” (Rodriguez, 1997) because they fail to explicitly delineate the sociocultural factors (i.e. race/ethnicity, socioeconomic status, culture, language) that may influence the beliefs and attitudes of preservice teachers. This oversight is important because negative beliefs and attitudes may be translated into inequitable science teaching and learning opportunities for diverse populations. In addition, these standards provide little guidance as to what practices may lead to the development of efficacious science teachers of *all* students. The primary purpose of this
study was to explore the effects of community-based service-learning on the self-efficacy beliefs of preservice elementary teachers regarding equitable science teaching. More specifically, the following research questions were posed.

*Research Questions*

**Question 1**

In what ways, if any, are the perceptions of preservice elementary teachers enrolled in a community-based science methods course with an embedded service-learning component different from those enrolled in two university-based science methods courses without a service-learning component with respect to their ideas concerning the characteristics of effective science teachers?

*Rationale.* Preservice teachers’ notion about what they consider to be effective science teaching is an aspired belief. These notions may affect preservice teachers’ confidence in their perceived ability to be effective science teachers of diverse student groups. Therefore, identifying characteristics preservice elementary teachers ascribe to effective science teachers is vital if science teacher education programs are to be successful in providing experiences that either support beliefs that are consistent, or challenge beliefs that may be inconsistent, with the equity principle articulated in science education reform initiatives (NRC, 1996). This study examined preservice elementary teachers’ perceptions of effective science teachers.

**Question 2**

What is the difference in the Personal Science Teaching Efficacy (PSTE) scores and Science Teaching Outcome Expectancy (STOE) scores among preservice elementary teachers enrolled in a community-based science methods course with an embedded
service-learning component and those enrolled in two university-based science methods courses with no embedded service-learning component?

**Rationale.** Elementary school is usually the first place most children experience science. Therefore, the beliefs and attitudes preservice elementary teachers possess about their ability to teach science to all students in an equitable manner is very important for effective science teaching and consequently student learning. Field experiences have been shown to increase the self-efficacy beliefs of preservice teachers (Wade, 1995; Weaver, Hounshell, & Coble, 1979; Woolfolk Hoy & Burke Spero, 2005). In addition, findings show that field experiences, such as service-learning in urban areas, challenge preconceived beliefs about diversity (Calabrese Barton, 2000) and positively influence preservice teachers’ self-efficacy beliefs (Wade, 1995). This study measured the effects of community-based service-learning on the self-efficacy beliefs of preservice teachers about equitable science teaching and learning.

**Question 3**

What science methods course experiences, if any, are identified by preservice elementary teachers as having a positive effect on the development of their self-efficacy beliefs concerning equitable science teaching?

**Rationale.** Despite the number of science classes they’ve had, many teachers feel uncomfortable and unqualified to teach science (Weiss, 1997). In addition, many teachers believe that diverse student groups are not capable of achieving high academic success in science (Gilbert & Yerrick, 2001; Gomes & Tabachnick, 1992; Stegemiller, 1989). Thus, teachers enter their professional careers unconfident in their ability to teach science to diverse populations. Bandura (1997) states that there are four sources that
influence the self-efficacy beliefs of preservice teachers. Mastery experiences are the most powerful of the four sources. Community-based service-learning is one mastery experience that allows preservice teachers to connect theory with practice and interact with culturally diverse students in authentic environmental settings, thereby challenging preconceived beliefs about their abilities to be efficacious science teachers for all students. This study investigated what course experiences, if any, preservice elementary teachers identified as having a positive, or negative, effect on their self-efficacy beliefs about equitable science teaching and learning.

*Question 4*

How do preservice elementary teachers’ beliefs about multicultural science teaching change, if at all, over the course of a semester?

*Rationale.* Students participating in service-learning are more likely to feel as though they can make a difference in the lives of their students, regardless of their students’ backgrounds (Eyler & Giles, 1999). Boyle-Baise (2002) underscores this point by stating, “when…service learning is located in and responsive to culturally diverse and low-income communities, it can connect future teachers with constituents for multicultural education, alert them…to community resources for teaching, and help them understand the educational concerns of their future students” (p. xi.). Inasmuch as service-learning has been determined to have a positive effect on preservice teachers’ attitudes toward multicultural teaching (Boyle-Baise, 2002; Wade, 1995, 2000), this study sought to document the influence of community-based service-learning on preservice elementary teachers beliefs about multicultural science teaching.
Significance of Study

Research indicates that teacher education programs have had little impact on preservice teachers’ personal belief systems (Kagan, 1992). Ladson-Billings (1994, 2000) laments the fact that many teachers report that their preservice preparation programs did little or nothing to equip them with the necessary skills required to effectively teach today’s diverse populace. Similarly, Raizen & Mechelsohn (1994) posit that science methods courses have been ineffective in changing the way science is taught in the elementary classroom, especially in multicultural settings.

In science education, researchers have studied the effect of field experiences on preservice teachers’ science teaching efficacy (Morrell & Caroll, 2003; Plourde, 2002). However, no study has documented the effect of field experiences on preservice elementary teachers’ self-efficacy beliefs about equitable science teaching and learning. Similarly, few studies have documented the effect of field experiences on preservice science teachers’ beliefs about equitable science teaching (i.e. multicultural science teaching). Those studies that have been conducted have focused primarily on secondary science teachers (Calabrese Barton, 2000; Rodriguez, 1998b; Yerrick & Hoving, 2003). Furthermore, no study has researched the effect of community-based service-learning on preservice elementary teachers’ self-efficacy beliefs about equitable science teaching and learning.

Kyle (1994) asserts that science educators must focus on the process of educating teachers in order to prepare science teachers for a diversity of cultures in the classroom environment. Similarly, Brand and Glasson (2004) concluded from their research that teachers’ beliefs must be taken into consideration to reform science education --
especially those beliefs related to multiculturalism. As a final point, underscoring the
importance of self-efficacy and science teacher reform, Czerniak and Chiarelott (1990)
argue, “science anxiety and efficacy and strategies that reduce anxiety and increase
efficacy are worthy of attention in teacher education if we wish to improve the quality,
quantity, and success of science curriculum and instruction” (p. 55). By infusing
community-based service-learning into a science methods course for preservice
elementary teachers, this study sought to provide the science education community with
teacher education practices that would positively influence the self-efficacy beliefs of
preservice elementary teachers in regard to teaching science in an equitable way (see
Figure 1).
Figure 1. Conceptual Framework for a Study of Beliefs and Equitable Science Teaching and Learning

Science Teaching Efficacy about Equitable Science Teaching and Learning (Personal Self-Efficacy and Outcome Expectancy)

Beliefs about Multicultural Science Teaching

Perceptions Effective Science Teachers

Course Experiences

May affect

May affect

May affect

Mastery Experiences

Vicarious Experiences

Emotional Physiological Cues

Verbal Persuasion

Community-Based Service-Learning

University-Based w/ no Service-Learning
Definition of Terms

Attitude: Positive or negative feelings based on beliefs

Behavior: Actions implemented by individuals based upon their beliefs and attitudes

Belief: Habits of mind people hold to be true

Culture: The values (what one believes is important), beliefs (what one holds to be true), and norms of an individual (ones’ perceptions of how things should be done)

Didactic Instruction: Engaging, diverse, or innovating instructional methods

Diversity and Diverse Learners: Individuals from diverse racial/ethnic, socioeconomic, language, and cultural backgrounds

Equality: Treating all students the same

Equity: Treating students fairly by taking into account differences (e.g. different ways of knowing, different ways of learning, different ways of assessing content mastery)

Ideological belief: An individual’s beliefs and value system

Multicultural science teaching: Pedagogical practices that link science content to students’ lived experiences in authentic, meaningful ways and communicate the remarkable contributions of various cultures to the science curriculum. These practices also exemplify what should be done to ensure that diverse groups have equitable access to quality science instruction. For the purposes of this study, the phrases equitable science teaching, inclusive science teaching, and multicultural science teaching will be used interchangeably

Pedagogical belief: An individual’s perception about what constitutes effective science teaching

Science Teacher Outcome Expectancy: Belief that effective teaching will have a positive effect on student learning

Personal Science Teacher Efficacy: Belief in one’s ability to be an effective teacher

Self-efficacy beliefs: Beliefs in one’s ability to organize and execute required actions to manage future situations

Service-learning: A pedagogical tool that connects academic content to community service focusing on critical reflective thinking and civic responsibility; also referred to as community-based service learning
CHAPTER TWO: LITERATURE REVIEW

Introduction

All students, regardless of their backgrounds, deserve access to just and equitable learning opportunities. Not only must these learning opportunities include the equitable access to resources, they must also include access to efficacious teachers of diverse student groups. Freire (1974) argued that racism, classism, equity, and social justice issues permeate and influence every educational institution. White teachers, who currently make up eighty percent of the teaching population (NCES, 2003) and those enrolled in teacher preparation programs (Hodgkinson, 2002), have had little to no exposure to education in which the impact of race, ethnicity, and class on classroom practices and student development have been systematically analyzed (Sleeter, 1992). This is especially true of science education. Consequently, science teacher educators (Atwater, 1996; Lee, 1999; Rodriguez, 1998a, 1998b) are mindful of the need to address social justice issues in the preparation of effective science teachers.

At the present, many school-aged students have very different cultural and social histories than most classroom teachers (Hodgkinson, 2002). Many organizations are aware of this incongruence, and therefore have made teacher preparation an essential priority for science education reform (AAAS, 1989; NRC, 1996; NSTA, 2004). However, these organizations have implemented standards that fail to explicitly delineate sociocultural factors that may preclude the attainment of their primary vision, the
production of a scientifically literate populace. More specifically, science reform documents have failed to address how sociocultural factors influence and shape teachers’ beliefs and attitudes, thereby influencing the academic success, or lack thereof, of all students.

Despite this oversight, science teacher educators must find ways to unmask the preexisting belief systems that preservice teachers bring to diverse classrooms (Bryan & Atwater, 2002; Riggs, 1991; Rodriguez, 1998b; Tilgner, 1990; Weiss, 1997). If teacher educators remain remiss in addressing this issue, preservice elementary teachers will be left with “no critical lens, vocabulary, or social imagery, through which they can see themselves as actors in creating an oppositional space to fight for equality and social justice” (Giroux, 1999). Only through a deeper understanding of these beliefs can teacher educators provide preservice teachers with experiences that will cultivate the development of positive attitudes toward equitable science teaching and learning.

Moreover, until it is acknowledged how teacher beliefs facilitate unjust practices and undermine equitable science teaching and learning, and what practices, if any, alter the ideological and pedagogical beliefs of preservice teachers about equitable science teaching and learning, “science for all” will remain an oxymoron.

Educational equity is used as the conceptual background of this inquiry; hence the themes of race/ethnicity, socioeconomic status, language, and culture are central to this review. The ensuing literature review will begin with a historical overview of science education and science teacher education reform efforts, followed by a definition of educational equity. Subsequent sections will address sociocultural factors that impede the attainment of educational equity, i.e. the demographic divide between teacher and
student backgrounds, teacher beliefs, and self-efficacy beliefs. A summary of the key points and implications for science teacher education concludes the chapter.
Science Education Reform

In 1981, the status of science education was documented with the release of Project Synthesis (Harms & Yager, 1981). One of the goals of this project was to assess whether or not the United States’ educational system was producing scientifically literate citizens. After compiling information from science teachers and National Science Foundation studies, Harms and Yager concluded that scientific literacy was not being promoted amongst all students. Specifically, scientific knowledge was being discretely disseminated to certain student groups. Similarly, "A Nation at Risk: The Imperative for Education Reform” (National Commission on Excellence in Education [NCEE], 1983) provided renewed interest in educational reform with its declaration “The educational foundations of our society are presently being eroded by a rising tide of mediocrity that threatens our very future as a nation and a people…We have, in effect, been committing an act of unthinking, unilateral educational disarmament” (p. 22). It also underscored the fact that the United States’ educational system was producing scientifically illiterate citizens. Another weakness identified in the report was that of teacher quality and effectiveness. Findings indicated that teachers lacked the content knowledge and pedagogical skills required to affect the needed change in student achievement (NCEE, 1983). As a result, this report demanded higher academic standards and student achievement and foreshadowed the accountability movement.

In response to the call for reformation, the American Association for the Advancement of Science (AAAS) stated that scientific literacy for all students was of the utmost importance and set out to define a codified knowledge base for curricula and pedagogy. Concurrently, the National Education Goals Panel [NEGP] created six broad
goals to address the concerns raised in the *Nation at Risk* report. These goals were summarized in the *National Education Goals Report: Building a Nation of Learners*. The report’s overarching purpose was to establish greater accountability for schools and align academic goals, instruction, curricula, and assessment.

Furthermore, amid growing concerns about the preparation of the nation’s youth, Project 2061 of the American Association for the Advancement of Science (AAAS) published *Science for All Americans* (AAAS, 1986). This document described what understandings and “habits of minds” were essential for all citizens to possess in a scientifically literate society. In 1993, the National Research Council established the National Committee on Science Education Standards and Assessment (NCSESA). Its responsibility was to oversee standards development in teaching, assessment, and science content. It was also during this time that AAAS’s Project 2061 published *Benchmarks for Science Literacy* (AAAS, 1993; NRC, 1996). It should be noted that the technological advances of other nations created a need for *everyone* to become scientifically literate. Therefore, Project 2061 concluded that *all* children need and deserve basic education in mathematics, science and technology.

In 1992, the National Science Teacher Association (NSTA) requested that the National Research Council (NRC) provide a framework that would lead to the production of a scientifically literate populace. In a review of the current conditions of the United States educational system, the council concluded that the major cause of scientific illiteracy was the incongruence between teaching standards, teacher beliefs, and the nation’s educational structure. Therefore, the council set out to create a positive image of
science, set goals for academic achievement, support effective teaching methods and
teacher professionalism, and increase accountability measures.

The year 1994 marked the establishment of the *Goals 2000: Educate America
Act*, which was signed into law by President Bill Clinton. This act declared that by the
year 2000, America’s students would be first in the world in mathematics and science
achievement. To help with the attainment of this goal, the National Research Council
published the *National Science Education Standards* (NRC, 1996). These standards also
emphasized the fact that all students deserve equal opportunities to become scientifically
literate. However, equitable educational opportunities must be made available to all
students if “science for all” is to be an attainable goal.

Today, there is widespread affirmation that many of the nation’s schools are
failing their students, especially students from racially, culturally, ethnically, and
linguistically diverse backgrounds and low-income backgrounds (Darling-Hammond,
1996). In 1999, Richard Riley, then U.S. Secretary of Education, publicly acknowledged
these discrepancies at the Improving America’s Schools Conference in Chicago, Illinois.
He noted that many African American, Latina/o, and other minority children are still
denied the quality education they deserve (Riley, 1999). The fourth annual 50-state
report by *Education Week, Quality Counts 2000*, underscored this point. This document
meticulously unveiled the poor performance of many students, especially those who
attend schools in urban areas. Additionally, it posited that teachers are ill-equipped to
deal with the complexities of teaching diverse populations. Consequently, lack of teacher
preparation is one of the principle factors “contributing to low academic achievement for
a vast majority of minority and low-income children” (Ukpokodu, 2002, p. 25).
Many reports and studies support the development of rigorous standards of achievement and increased accountability (Darling-Hammond, Wise, & Klein, 1999; National Board for Professional Teaching Standards [NBPTS], 2000; National Council for Accreditation of Teacher Education [NCATE], 2004; National Commission on Teaching and America's Future [NCTAF], 1996). Yet, after decades of reform efforts, academic achievement continues to remain low and the persistent academic gap between students of color and white students, along with urban and suburban schools, remains problematic. In addition, the American educational system is still producing citizens who are scientifically illiterate. Walberg (2003) argues, “Despite the policy crescendo of state standards, lists, and accountability, there is a gulf between what teachers teach and what is called for in the kind of standards-based reform represented in NCLB. For accountability to work, it must invade the primary sanctuary of today’s schools: the classroom.” (p. 79).

Science Teacher Education Reform

In science education, equity and excellence is an underlying principle of reform initiatives. However, science education reform cannot occur without the restructuring of teacher education. The National Science Education Standards state, “The current reform effort requires a substantive change in how science education is taught; an equally substantive change is needed in professional development practices” (NRC, 1996, p. 56).

The National Commission on Mathematics and Science Teaching for the 21st Century (Glenn Commission) released its final report, titled “Before It’s Too Late,” in September, 2000. The following statement was issued in its conclusion: “the current preparation that students in the United States receive in mathematics and science is, in a
word, unacceptable” (U. S. Department of Education, 2000, p. 7). The Glenn Commission implied that the pronouncement about our children being “first in the world in mathematics and science achievement” by the year 2000 (p. 12) was unrealistic. Disaggregated data from the National Assessment of Educational Progress (NAEP) delineated a picture of continuing poor performance, especially by minority student groups. In fact, the Glenn Report goes on to state that “…our students are losing ground” (p. 9). The report suggests that with better teacher preparation, students’ academic achievement in mathematics and science in the United States can be improved. More specifically, it asserts that “the most powerful instrument for change, and therefore the place to begin, lies at the very core of education, with teaching itself” (p. 5). Needless to say, despite reform efforts and the accountability movement, the nation failed to meet any of its goals, presented in the Goals 2000: Educate America Act, by the year 2000 (Walberg, 2003).

In the field of teacher education, the Interstate New Teacher Assessment and Support Consortium (INTASC) and the National Council for Accreditation of Teacher Education (NCATE) have defined standards and performance indicators that refer to the teachers’ responsibilities to promote equitable educational opportunities for all students (Irvine, 2003). Standard Three of INTASC clearly states that teachers should comprehend and appreciate how students differ in their approaches to learning. Consequently, instructional approaches should be adapted to meet the learning needs of diverse students. Additionally, content-focused groups such as the National Council of Teachers of Mathematics (NCTM) and National Science Teacher Association (NSTA) have emphasized similar standards directed at reducing the academic achievement gap.
between white students and racially/ethnically diverse students. Furthermore, the National Science Education Standards (NRC, 1996) and the American Association for the Advancement of Science’s Project 2061 Science for All Americans (AAAS, 1989) place teacher pedagogy front and center of science reform efforts. Science for All (AAAS, 1989; NRC, 1996) is a reform movement intended to promote the inclusion of all students. Its major goals are to: 1) provide learning opportunities for all students, particularly those who continue to be underrepresented in the field of science and science education; and 2) produce a scientifically literate populace able to make informed personal choices while appreciating the world around them (AAAS, 1989; NSES, 1996). Moreover, the role of excellence and equity is a principle underpins the National Science Education Standards. This principle charges teachers with the responsibility of reducing the academic gap between diverse student groups and their white counterparts by providing educational opportunities that are equally accessible to all students, regardless of their backgrounds. However, it fails to take into account the inherent differences between equity and equality that may hinder the attainment of this goal.

Educational Equity

In a classroom of thirty children a teacher has one student who is visually impaired, one who is wheelchair-bound, one who has limited proficiency, and one who is intellectually gifted. If the teacher presents identical work in identical ways to all of the students, is she dealing equitably or inequitably with children? (Ladson-Billings, 1994, p. 33)

In addition to high academic benchmarks, equity is emphasized as a key principle in standards-based and systemic reform efforts. However, educators have different perspectives about what equity means. For that reason, the definition of equity has
evoked many discussions and debates. Equity, as defined by Merriam-Webster’s Online Dictionary (2005), has to do with freedom from favoritism or bias. The Division of Elementary, Secondary, and Informal Education (1997) defines equity as the equal distribution of resources or equal quality of educational experiences. According to Grant and Secada (1995), equity involves the examination of social arrangements underpinning schooling to determine its interrelatedness with issues of social justice. Conversely, “equality of educational opportunity usually refers to efforts to ensure that diverse groups of learners, in the aggregate, are treated the same (i.e., equally) at one of three junctures in the education system—its input, processes, or outcomes” (Secada, 1994, p. 23). Kohl and Witty (1996) posit that equity is a value and is not interchangeable with the word equality. Grant and Ladson-Billings (1997) argue that equity in education must go beyond equal opportunity. It should also address the learner’s individual differences and needs in curricula and pedagogy.

Equity is associated with being just and fair, whereas equality is coupled with sameness (Lee, 1999; Secada, 1994). The difference between the aforementioned terms is very important when considering educational restructuring, because “in educational practices, equality in terms of the same opportunities and outcomes often dominates” (Lee, 1999). Science reform efforts target equal opportunities, yet disregard issues of social justice that hinder diverse student groups from reaching higher academic standards.

Equity and Science Education

The marginalization of diverse student groups in science education, because of unequal access to quality educational opportunities, has become an important issue for policy makers and the American public. To address this concern, the National Research
Council (NRC, 1996) and the American Association for the Advancement of Science (AAAS, 1989), respectively, released the following policy statements:

Science is for all students. This principle is one of equity and excellence…All students, regardless of age, sex, cultural or ethnic background, disabilities, aspirations, or interest and motivation in science, should have the opportunity in science to attain higher levels of scientific literacy. [This principle] has implications for program design and the education system…to ensure that the Standards do not exacerbate the differences in opportunities to learn that currently exist between advantaged and disadvantaged students. (NRC, 1996, p. 20)

When demographic realities, national needs, and democratic values are taken into account, it becomes clear that the nation can no longer ignore the science education of any student. Race, language, sex, or economic circumstances must no longer be permitted to be factors in determining who does and does not receive a good education in science, mathematics, and technology. To neglect the science education of any (as has happened too often to girls and minority students) is to deprive them of a basic education, handicap them for life, and deprive the nation of talented workers and informed citizens—a loss the nation can ill afford. (AAAS, 1990/1989, p. 214)

Nevertheless, to this day, quality science education for all students remains an elusive aspiration (Weiss, 1997). One of the most compelling equity-related concerns is the underrepresentation of ethnically diverse minorities and women in science related fields. For example, although African Americans, Native Americans, Latinos/as, and other ethnically diverse individuals make up approximately 18% of the U.S. population, less than 5% of those employed in science related fields are ethnic minorities (Barba, 1998). Similarly, women make up only 33% of those employed in science related fields (Ritter, 1999), even though they comprise 51% of the U.S. population (Ritter, 1999). This underrepresentation has been attributed to various factors such as lack of student motivation, race, gender, socioeconomic status, personality characteristics, science anxiety, white male
domination, lack of minority role models, lack of quality academic preparation, and tracking and grouping practices (Barba, 1998).

A second key concern is that of student grouping. Research studies show that students who are grouped and enrolled in lower ability classes, the majority of whom are racial/ethnic minorities, are less likely to be given equitable opportunities to learn quality science (Gilbert & Yerrick, 2001). Yet, Weiss (1997) found that 30% of teachers in grades 1 through 4 believed that students should be grouped according to their academic ability. Considerable evidence also suggests that students who are labeled “low-ability” are not given access to the same educational resources as those students teachers perceive as more advanced (Weiss, 1997; Gilbert & Yerrick, 2001). Since teachers’ beliefs about equity are reflected in their instructional approaches, the underrepresentation of minorities in science related fields can also be attributed to teachers who possess beliefs that counter the principle of equity.

A third concern is that of academic achievement. Alberto Rodriguez’s (1998a) analysis of the persistent academic gap between the science scores of white students and students of color indicates that the U.S. is not a meritocracy. International studies revealed that U.S. students performed poorly on science assessment instruments (Lynch, 2000; Rodriguez, 1998a). More specifically, disaggregated data from the 1999 TIMSS-Repeat report showed that the scores of urban students were below the international average. At the national level, disaggregated data from “Nation’s Report Card” (NCES, 1996, 2000) revealed that the academic gap between students of color and white students persists at the elementary level (see Figure 2).
Figure 2. Average scale score for grade 4, Race/ethnicity

In addition, those students who were eligible for free and reduced lunch performed well below those who were not. Many reasons have been put forth to explain these disparities. According to Oakes, Ormseth, Bell, and Camp (1990), a disproportionate number of low-income and minority students are using curricula designed for low-ability students. In addition, these students have limited access to the best qualified science teachers. Rodriguez (1998a) contends that the U.S. educational system has been structured to benefit the hegemony. In addition, the education system’s failure to disaggregate science scores amongst racial/ethnic minorities may reinforce preconceived stereotypes about diverse groups. For example, many Americans believe that Asian groups represent the “model minority” in science and mathematics education, whereas other ethnic/racial minority groups are predicted not to do as well. However, a closer look at the differences that exist within specific ethnic groups labeled Asian
revealed that Southeast Asian refugees face many challenges, including inadequate schooling and illiteracy (Rodriguez, 1998a). Presuppositions of intelligence may lead to high teacher expectations for one racial/ethnic group and low teacher expectations for another. Therefore, Rodriguez asserts that America’s existing educational structure marginalizes racially/ethnically and culturally diverse students. He vehemently states that America’s meritocracy myth must be “busted open” to promote the participation and high academic achievement of all students.

Finally, many researchers assert that because all students are learning the same science content, based upon the hegemonic lens of Western traditions, and are provided with the same opportunities to demonstrate mastery of content knowledge, in the form of uniform assessment practices, government bodies, reform initiatives and educators have failed to recognize and value the lived experiences and different ways of knowing diverse student groups bring to the science classroom (Atwater, 1996, 2000; Aikenhead, 1997; Lee, 1999). This invalidation may be equated to the rejection of students’ culture. Simply put, when policy makers, educators, and the science curriculum reject students’ cultures, experiences and ways of knowing, students themselves feel invalidated, silenced, and marginalized (Aikenhead, 1997; Atwater, 2000; Lee, 1999). When diverse students fail to see themselves in authentic and meaningful ways, the consequences include unjust outcomes (Lee, 1999).

Educational equity is a key construct of multicultural education in the United States (Banks, 2002). Within science education, the idea of educational equity has been embedded in the rhetoric of “science for all,” an important tenet of science education reform (AAAS, 1989; NRC, 1996). Although reform documents state that science equity...
is for all students, they fail to explicitly articulate why equity is an important tenet of science education reform. In addition, these documents state that teacher educators are to build on the preexisting attitudes of preservice teachers, yet fail to acknowledge that these attitudes may be underpinned by beliefs that limit “all” students from learning science in an equitable way. Lee and Lukyx (2006) underscore this point by stating, “Equitable learning opportunities [will] occur when school science [including science teachers] values and respects the experiences these [non-mainstream] students bring from their home and community environments, articulates their cultural and linguistic knowledge with science disciplines, and offers education resources and funding to support their learning at a level comparable to that available for mainstream students. Provided with equitable learning opportunities, these students are capable of demonstrating science achievement, interest, and agency” (p. 4). Moreover, these equitable learning opportunities must include access to teachers who have been prepared to teach science effectively to a multicultural student population.

Demographic Divide

The educational community is faced with a demographic imperative to serve an increasingly diverse school-aged population. In addition, teachers and teacher educators must address, and ameliorate, the educational inequalities that permeate America’s educational system. Recent statistics indicating the increase in diversity of the student population, consistency of a homogenous teaching force, and the persistent academic gap among diverse student groups support this demographic imperative.

In 1994, students of color accounted for 33% of the elementary and secondary school-aged population (NCES, 2002). In 2002, this figure increased to 39%. Harold
Hodgkinson (2002), a well-known educational demographer, projects the following demographic changes:

Future population growth in the United States continues to be uneven—61% of the population increase in the next 20 years will be Hispanic and Asian, about 40% Hispanic and 20% Asian; but then, as now, 10 states will contain 90% of the Hispanic population, 10 will contain 90% of the Asian population, and 7 will do both. Half of all Mexican Americans live in California! In fact, most of this increased diversity will be absorbed by only 300 of our 3,000 [U.S.] counties. If we look at what changes America, it is 1 million immigrants a year, 4 million births, 2 million deaths, and 43 million people moving each year. (pp. 103-104)

If these projections hold to be true, by the year 2035, students of color will comprise 50% of the school-age population. Similarly, by 2050, students of color will make up close to 57% of all U.S. students (U.S. Department of Commerce, 1996; Villegas & Lucas, 2002) (see Figure 3) and the number of students whose first language is something other than English will be greater than ever before (NCES, 2003). In addition to the aforesaid projections, Villegas and Lucas (2002) note that the U.S. has the highest number of children living in poverty, 8,334,825 (NCES, 2000), when compared to other advanced nations. Hodgkinson (2002) calls attention to this point by reporting that “Minorities…make up the highest percentage of poor kids, about 38%, compared to only 18% of White children” (p. 103). Hodgkinson also notes that many students come from non-traditional homes. Instead of the traditional two-parent homes, single parents, same sex parents, or grandparents head these households.
Meanwhile, despite efforts to recruit students of color into the teaching profession, enrollment patterns among African American, Latina/o, and Asian cultures continue to decline (Collier, 2002; Delpit, 1995; Hodgkinson, 2002; NCES, 1996; Nieto, 2000). Accordingly, the teaching force is predicted to remain homogenous; that is white, monolingual, middle-class, and female (Banks, 2000; Irvine, 2003; Nieto, 2000). The American Association of Colleges of Teacher Education (1999) reported that 87% of elementary and secondary schoolteachers are white. Recent statistics verify that teachers of color account for only 16% of the current teaching population (National Education Association [NEA], 2004). On that same note, research on prospective teachers indicates that this population mirrors the current teaching force (Association of Colleges for Teacher Education [AACTE], 1999; Hodgkinson, 2002; Ladson-Billings, 1999). White students represent 80%-93% of students currently enrolled in teacher preparation programs (see Figure 4).
In addition to the sociocultural mismatch that exists between today’s diverse student population and their teachers, the chasm between the achievement scores of white students and students of color on reading, mathematics, and science assessment instruments continues to persist (NCES, 2000). In a study conducted by the Third International Mathematics and Science Study (TIMSS), data revealed the inequalities in science scores between poor, predominantly minority schools and wealthy, predominantly white schools (Mullis, Martin, Gonzalez, & Chrostowski, 2004). Students of color scored at the lowest levels. Similarly, in grade 4, students in central city locations had lower average scores on math and science achievement tests than those in urban fringe/large towns or rural/small town locations (NCES, 2000). An equally related issue is that of those grade 4 students who were eligible for free/reduced lunched, 58% remained below the basic level for science achievement. Villegas and Lucas (2002) concluded that “the consistent gap between racial/ethnic minority and poor students and
their White, middle-class peers…is indicative of the inability of the educational system to effectively teach students of color as schools have traditionally been structured” (p.9).

This demographic divide (Gay & Howard, 2001) illuminates the endemic challenges faced by teachers and students to cross cultural borders; that is understand, appreciate, and utilize the experiences that diverse students bring to the science classroom (Jegede & Aikenhead, 1999). If border crossing does not occur, a possible consequence may be the development of ineffective instructional practices that lead to the disenfranchisement of diverse student groups (Banks, 2002; Delpit, 1995; Gay, 2000; Hilliard, 1992; Irvine, 2003; Ladson-Billings, 1994; Nieto, 2000; Sleeter & Grant, 1999). In addition, this demographic divide creates a sense of urgency for teacher educators to provide science teachers with an educational tool kit, ideological and pedagogical, requisite for teaching science in an equitable manner. Reform initiatives and science teacher education programs must revamp their existing approaches in order to adequately prepare teachers to work effectively with students from diverse racial, ethnic, class, language, gender, disability, and cultural backgrounds.

However, studies indicate that the beliefs of many prospective teachers are resistant to pedagogical practices inclusive of multiculturalism (Cochran-Smith, 1991; Rodriguez, 1997, 1998b; Yerrick & Hoving, 2003). In science education, comments such as “if women and minorities want to be successful in science, then they are just going to have to work as hard as white males” (Rodriguez, 1997, p. 22), have been recorded and are deeply entrenched in the presuppositions that prospective teachers possess before they enter the classroom.
Teacher Beliefs

A teacher’s judgment and treatment of students has a tremendous impact on students’ emotional and educational development and outlooks toward science. These judgments impact lesson planning, assessment, and evaluation (Bryan & Atwater, 2002) and thus may act as gatekeepers to educational resources (Cochran-Smith, 1997; Oakes & Lipton, 1999). Therefore, more attention must be placed on gauging the interconnectedness of teachers’ beliefs and professional practices. Pintrich (1990) underscores this sentiment by writing that beliefs will prove to be the most valuable psychological construct in teacher education. He also calls attention to the pivotal role that beliefs will play in how teachers interpret and implement pedagogical knowledge. Beliefs are habits of mind that structure one’s thinking and actions (Nespor, 1987; Pajares, 1992; Richardson, 1996). They are cognitive constructs that have been accepted as truth by the individual holding them (Richardson, 1996) and are underpinned by personal experiences or cultural transmissions of knowledge (Bryan & Atwater, 2002; Nespor, 1987). Dewey (1933, 1938) describes beliefs as tested values. He states that although we have no tangible knowledge of the belief’s worth, we act upon the belief with sufficient confidence and accept it as true, as knowledge, and sometimes questionable.

Belief systems are structured groups of beliefs (Bryan & Atwater, 2002). Like beliefs, these systems also possess distinguishing attributes (Nespor, 1987; Pajares, 1992; Rokeach, 1968). In particular, belief systems are confidently maintained by the individual holding them, even when he or she is presented with factual information, or reasons, that challenge them. Some beliefs are more important than others because of
their connection with consequences. These ramifications are often associated with lived experiences. The more central the belief is, the more difficult is becomes to change (Bryan, 2002; Bryan & Atwater, 2002; Rokeach, 1968).

Bandura (1986, 1997) explains that individuals make numerous decisions throughout their lives, and that the best predictors of these decisions are the beliefs associated with them. Thus, an individual’s belief system ultimately determines his or her attitude. The resulting attitudes buttress action plans (behaviors) because people take action based upon what they believe. Since beliefs are thought to be valid predictors of instructional practices (Bandura, 1986; Pintrich, 1990; Enochs & Riggs, 1990), as well as precursors to change (Haney, Lumpe, Czneriak, & Eagan, 2002), it is only logical to conclude that teachers’ beliefs are crucial factors in the success of science education reform. The aforementioned information is supported by Bryan’s study of the nestedness of a prospective elementary teacher’s belief about science teaching and learning.

Using data collected from a larger study, Bryan (2002) constructed a profile of Barbara, a 21-year-old preservice elementary teacher enrolled in her senior year at a Midwestern university. Barbara’s profile was constructed from interview analysis, observations, and written documents. Data was gathered in two phases. Phase I involved data collection in the form of observations, discussions, and written reflections while Barbara was enrolled in a 16-week science methods course. Phase II involved collecting data in the form of interviews, teaching videos, and field notes while Barbara was in her student teaching semester. She taught 3rd grade in a small working-class town approximately 30 miles from the university’s campus.
Data analysis yielded the following results. Barbara’s profile consisted of three foundational beliefs and three dualistic beliefs. Barbara’s foundational beliefs were based on the preexisting beliefs she possessed before entering her science methods course and student teaching semester. These beliefs were comprised of the value of science and science teaching, the nature of science, the goals of science instruction, and pupil control. Her dualistic beliefs developed as a result of participating in the methods course, student teaching, and researcher interviews. These beliefs consisted of how children learn, the student’s role in the science classroom, and the teacher’s role in the science classroom.

Barbara placed a high value on learning and teaching science and viewed science concepts as factual. She believed that the goal of science was for students to know these facts. Barbara’s instructional style matched the belief that science was a set of facts that could be transmitted from teacher to student through lectures, telling, and sharing the right answer. In addition, she believed that the children’s role was to receive that information. Therefore, class time was devoted to fact-centered rote learning and seatwork. Barbara also believed that it was the teacher’s job to maintain control of social behavior, procedures, and student learning. However, based upon experiences in her science methods course, she also possessed beliefs that contradicted the pedagogical practices she was implementing in the science classroom.

Barbara believed in the value of hands-on experiences and discovery learning, which contradicted the abovementioned foundational beliefs. She felt that it was the teacher’s job to act as a facilitator, rather than a dictator, of learning. However, these beliefs were not implemented as much as her foundational beliefs, which were predicated on her past experiences before entering the methods course.
With over 12 years of school experience, preservice teachers enter teacher preparation programs with presuppositions that inform their instructional practices (Bandura, 1997; Bryan, 2002). Although some beliefs and belief systems are made explicit, many teachers hold implicit beliefs that they may not acknowledge or express until they are placed in an environment where these beliefs are unveiled. Beliefs are highly contextual and function as a filtering mechanism for interpreting new information (Pajares, 1992). Moreover, beliefs and attitudes are inextricably intertwined and may serve as the driving force behind a person’s actions (Bryan & Atwater, 2002; Richardson, 1996).

**Teacher beliefs and Science Teaching**

Reform documents, such as *What Matters Most: Teaching for America's Future* (National Commission on Teaching and America’s Future, 1996), the *National Science Education Standards* (NRC, 1996), and the Glenn Report (Glenn, 2000) challenge teachers to shift from a “hierarchical transmission-oriented” (Villegas & Lucas, 2002) style of teaching to one that is inquiry-based and inclusive of all students. Furthermore, science teacher education programs have the responsibility of assisting prospective teachers in: 1) planning inquiry-based activities; 2) facilitating and guiding student learning; 3) continually assessing, and reassessing, their pedagogy and student learning; 4) planning and developing school science programs; 5) fostering positive environments that enable science learning; and 6) creating communities of science learners that reflect the scientific enterprise (NRC, 1996, pp. 29-53). Yet, many studies in science education have documented the sometimes paradoxical relationship between teacher beliefs about learning and the instructional practices he or she implements (Czerniak, Lumpe, &
Haney, 1999; Lumpe, Haney, & Czerniak, 2000). Czerniak et al. (1999) concluded that science reform agendas must consider how teacher beliefs affect instructional practices. Their findings suggest that many preservice teachers disagree with the concept of teaching science any differently than the traditional, teacher-centered instructional method they experienced as science students (Bryan & Abell, 1999; Rodriguez, 1998b).

After analyzing data from a 1993 national survey of approximately 6,000 teachers, grades 1-12, and 1,250 schools, elementary through high school, Weiss, Matti, and Smith (1994) found that when elementary teachers were given a list of possible objectives for their science classes, the most heavily emphasized objective was the learning of basic concepts (Weiss, 1997). This was especially true for those students teachers perceived as “low-ability” students. Similarly, despite the fact that national science standards call for an increased emphasis on higher-order thinking skills and a decreased emphasis on fact-based learning, Weiss (1997) reported that many elementary teachers emphasized fact-based knowledge in their classes. One out of every three elementary classes placed increased importance on the fact-based dissemination of scientific knowledge. Furthermore, although national science standards recommend that students engage in more inquiry-based activities, this type of lesson only made up one-fourth of the instructional practices being implemented in elementary school science (Weiss, 1997).

In their ethnographic study, Gilbert and Yerrick (2001) described the beliefs and practices of a white male teacher, Mr. Smith, in a lower-track earth science class located in a rural setting, where the majority of students were African American. Mr. Smith’s beliefs about his students’ lack of knowledge underpinned his curricula choices and
pedagogical practices. The students were aware of his beliefs, and thus behaved accordingly. Mr. Smith believed that his students knew very little about anything. Gilbert and Yerrick recorded the following comments from Mr. Smith’s students: “He also thinks, like the whole class is, like, ain’t smart, though. It’s the way he acts towards us you know; it’s like he’s got to explain everything elementary, you know?” (p. 586). Another student responded, “That makes me sad. That’s the reason why I don’t do anything when he does that to me. I get mad at him” (p. 586). The students also noticed that Mr. Smith treated their class and the “higher level” class differently, citing better equipment and materials used with other classes. Findings by Gilbert and Yerrick (2001) confirmed students’ beliefs.

Qualitative data indicated that honors classes had the best teachers and incorporated a minimum of one lab per week. In addition, minority students represented less than 20% of student enrollment in these classes. Conversely, lower track science classes had a student population of 30 or more students, higher drop out rates, fewer, if any, lab experiences, and minority students comprised 75% of student enrollment. Instead of holding all students to high academic standards, Mr. Smith chose to represent science through a watered-down curriculum by disseminating fact-based information, absent of meaningful content to his lower-track students. They were rarely given opportunities to construct arguments and explanations.

National science education standards (AAAS, 1989; NRC, 1996) call for all students, regardless of their diverse backgrounds, to develop higher order thinking skills. This means that teachers must provide environments that foster a student’s ability to think critically, ask questions, plan and conduct investigations, and collect data.
Additionally, teachers should guide and facilitate learning by recognizing and responding to student diversity in ways that encourage “all” students to participate fully in science learning (NRC, 1996). However, this pedagogical imperative means very little to teachers who simply view science as the dissemination of a static set of facts or calculations (Gilbert & Yerrick, 2001; Weiss, 1997). The research studies discussed above underscore the point that teachers present science as a list of facts, absent of authenticity, especially when educating urban students.

The treatment of science as largely factual is an inaccurate representation of the nature of science. Within urban schools and lower-track classes, success in science is defined by a student’s ability to memorize, recall, and follow instructions (Atwater, 2000; Gilbert & Yerrick, 2001). In other words, urban students are only required to know the basics. This banking system ideology (Freire, 1974), which is used by ineffective teachers, diminishes students’ use of evidence and rational thought which are essential components of scientific literacy (AAAS, 1993; NRC, 1996). The development of these higher order thinking skills necessitates student exposure to inquiry-based instruction, which minority students are rarely afforded (Gilbert & Yerrick, 2001; Yerrick, 2000). Therefore, preparing teachers to produce scientifically literate citizens requires the educational community to recognize how beliefs serve as a critical lens for filtering and disseminating information. This lens informs ideological and pedagogical beliefs that are incongruent with reform efforts, and thus may impede equitable science practices.
Teacher beliefs and urban students

Preservice teachers enter teacher preparation programs with little to no interracial or intercultural experiences. Therefore, prior beliefs will significantly influence who they teach, how they teach them, and how they understand diversity (Sleeter, 1992). In addition, these beliefs will also determine whether or not “science for all” will be ultimately successful. Many teachers still subscribe to the belief that very few students, especially students of color, can be successful in science related fields (Atwater, 1999; Gilbert & Yerrick, 2001). As a result, urban students are frequently educated by ineffective teachers who do not believe they can learn or be academically successful.

Terrill and Mark (2000) documented the negative beliefs of preservice teachers towards children of color and second-language learners. They distributed a 37-item questionnaire to 97 undergraduate students enrolled in a Foundations of Education course during the summer of 1998. The survey consisted of two sections. The first section was used to identify teachers’ expectations for learners in three different school settings; European-American, African American, and Native American. The second section was used to obtain demographic information on the preservice teachers. Demographic data revealed the following information: 91% were between the ages of 18 and 27; the majority of them graduated from high schools where Whites constituted 87% of the student population; 65% were female; 89% were white; 51% were from suburban communities; 38% were from rural communities; 64% would prefer to teach at a white, suburban school; and 52% never spent any time in classrooms with students of color.

When Terrill and Mark applied the Marginal Homogeneity Test to the preservice teachers’ expectations section, results indicated a statistically significant difference
between teachers’ expectations for African American students and those for Caucasian
students. Preservice teachers expected more discipline problems, fewer gifted or talented
students, and lower levels of motivation from black students in urban schools. However,
the converse was found to be true for white students attending affluent, suburban schools.

Similarly, in a survey of 300 white preservice teachers, at Kutztown University,
regarding their beliefs about working in multicultural settings, Shultz, Nyehart, and Reck
(1996) found that many held negative perceptions of urban students. Descriptive
characteristics of urban students, used by these teachers, included lackadaisical,
unmotivated, violent, and emotionally unstable. In a study conducted by Burnstein &
Cabello (1989), findings suggest that 38% of the certified teachers sampled described
culturally diverse students as coming from a “deficient” culture as opposed to a
“different” culture.

Likewise, in a study of 47 students enrolled in an introductory elementary
education course, Scott (1995) found that preservice elementary teachers exhibited
stronger negative attitudes toward Native American students than towards other students
of color. In an attempt to sensitize preservice teachers to stereotypes and prejudices,
Scott arranged for students enrolled in an introductory education course, which she
taught, to attend a one-day workshop conducted by faculty at an urban school at a
Multicultural Gender Fair Laboratory Demonstrate Site. An opinion survey, “Images of
Ethnic Minorities,” was administered to preservice teachers to gather perceptions “from
the dominant White group concerning four racial/ethnic groups, African Americans,
Asian Americans, Hispanic Americans, and Native Americans” (p. 70). Survey results
revealed that 47% of the respondents did not believe that minorities were hard-working.
Thirty-two percent had problems believing that minorities were intelligent, however 91% thought that minorities were just as smart as whites, “which seems to contradict their feelings about intelligence” (p. 71).

In addition, several preservice teachers felt that minority groups had received more than they deserved economically. More specifically, they assumed that because Native Americans were allowed to operate gambling casinos, tribes were getting rich. Furthermore, even after lengthy discussions about the history of inequalities that existed within American society, preservice teachers continued to have problems with affirmative action policies. They felt that minorities would get their jobs; jobs for which they were unqualified. After dialoguing with preservice teachers about their concerns, Scott (1995) concluded that their apprehensions centered around the empowerment of underrepresented groups and that their resistance was fueled just as much by ignorance as it was fear.

The aforementioned studies document the negative beliefs and attitudes of preservice teachers toward diverse student groups. Although some beliefs may reside in the subconscious, the attitudes attached to these beliefs undergird teachers’ commitment to diverse students. In addition, they are crucial factors in the academic success of these students. Atwater (2000) and Yerrick (2001) posit that science teachers remain the most powerful influence on learning science in urban classrooms. Teachers’ beliefs are communicated through their attitudes and behaviors and may lead to the marginalization of urban students, preventing them from achieving academic success (Gilbert & Yerrick, 2001).
Assuming these teachers lack self-awareness about their own assumptions regarding racially, ethnically, and culturally diverse groups, which include deficit-thinking, this dysconsciousness (King, 1991), or subtle form of discrimination, prevents them from seeing or believing that all students, regardless of their backgrounds, can achieve. If teachers hold the dysconscious perception that some students are at a deficit due to culture, language, poverty, race/ethnicity, or behavior, just to name a few, and are incapable of high performance standards, it can lead to lowered teacher expectations. These low teacher expectations can lead to the exacerbation of existing inequalities. Given the research that indicates that beliefs are often translated into action (Bandura, 1997; Pajares, 1992), if students are placed in an environment where teachers expect little to nothing of them, these students are more likely to receive a less rigorous curriculum, be held to low standards, and be placed in special education classes (Harris, Brown, Ford, & Richardson, 2004) or lower track science classes (Gilbert & Yerrick, 2001; Yerrick, 2000).

Teacher Beliefs and Multicultural Science Education

Although some teachers have successfully adapted their instructional practices to meet the needs of today’s diverse classrooms, others have yet to embody the vision of multicultural science teaching (Atwater, 2000; Rodriguez, 1998b). Preservice teachers’ receptiveness of multicultural education or diversity issues is limited by their lack of cross-cultural knowledge and experiences (Boyle-Baise, 2000; Ladson-Billings, 1995; McCall, 1995; Pohan, 1996).

Multicultural education, as defined by Banks & Banks (2003), “is a field of study designed to increase educational equity for all students that incorporates, for this purpose,
context, concepts, principles, theories, and paradigms from history, the social and
behavioral science, and particularly from ethnic studies and women’s studies” (p. xii).
Not only do multicultural theorists want to improve race relations, they also aim to help
all students acquire the skills, knowledge, and attitudes needed to actively participate in a
multicultural society. Atwater (1993) describes multicultural science education as “a
construct, a process, and an education reform movement with the goal of providing
equitable opportunities for culturally diverse student populations to learn quality science
in schools, colleges, and universities” (p. 32). However, few teachers understand the
complexities that may be associated with providing equitable opportunities to learn
science to an increasingly diverse school-aged population. If reform efforts are to
address the needs of a multicultural society, science teacher education programs must
infuse multicultural education throughout student coursework and address the negative
beliefs and attitudes exhibited by many teachers toward diversity.

In a review of the literature on the interrelatedness of preservice teachers’ beliefs
about multiculturalism and science education, Bryan and Atwater (2002) contend that
science teacher preparation programs should address three categories of beliefs if
“science for all” is to be an attainable goal. These three areas are student characteristics,
the influence of external factors on learning, and how teachers respond to diversity.
Their literature review illuminated the fact that many preservice teachers thought that
diverse students were less capable than white students of achieving high academic
standards due to a lack of inner control. Teachers ascribed this lack of control to
students’ cultural environments rather than to their beliefs and classroom environment.
In addition, preservice teachers were unaware of the incongruence between students’
lived experiences and the school curriculum (Bryan & Atwater, 2002). They did not believe that implementing an inclusive curriculum, or multicultural curriculum, was part of their job description. Bryan and Atwater (2002) concluded that most preservice teachers enter their undergraduate programs with little to no intercultural experiences and with beliefs and assumptions that undermine the goal of providing equitable educational opportunities for all students.

Gess-Newsome (1999) conducted a study in an elementary science methods course that examined the perceptions of preservice elementary teachers regarding multicultural curricula that included the contributions of diverse cultural groups to the field of science. The majority of participants in this study were white, middle-class females. The results of the study showed that these teachers possessed a positivistic view of teaching, knowledge, and learning; that is they believed the goal of science teaching was to help diverse students conform to Western standards and eliminate as much diversity as possible.

In a similar study, Yerrick and Hoving (2003) investigated preservice science teachers’ beliefs about science teaching and learning in a field-based secondary science methods course. These preservice teachers, 95% of whom were white, worked predominantly with rural black children. Two discrete categories of teachers emerged by the end of the study: 1) those who exhibited an ability to reflect on and revise their pedagogical practices, based on their environment, and engage in the production of new teacher knowledge (producers), and 2) those who rejected efforts to shift their ideological and pedagogical beliefs. Instead, they chose to reproduce their own educational experiences (Lortie, 1975) with a new student population (reproducers). If one
juxtaposes Yerrick and Hoving’s study with Rodriguez’s year-long study in a science methods course with white preservice secondary science teachers, the following two forms of resistance are applicable: “resistance to ideological change and resistance to pedagogical change” (Rodriguez, 1998b). As evidenced by several teachers who resisted an ideological change, teacher resistance often manifested itself into feelings of defensiveness, disbelief, guilt, and shame (Rodriguez, 1998b). These emotions emerged when teachers were asked to confront racism and other oppressive social norms in science education during class discussions. Resistance to pedagogical change, which was also exhibited by the same teachers, was attributed to the dissonance preservice teachers felt by having to cover the curriculum, maintain classroom control, and conform to the standards of both cooperating teachers and university supervisors (Rodriguez, 1998b).

Brand and Glasson (2004) explored the interrelatedness of belief systems, as it related to ethnic and racial identities in early life experiences, and views about equitable science teaching and learning for diverse populations. Three preservice science teachers, enrolled in a graduate licensure program, participated in the study; an Asian male from a suburban environment, a white male from Rural Appalachian environment, and an African American male from an urban environment. Using ethnographic methodology, results suggested that these preservice science teachers were hesitant in embracing a multicultural science curriculum because of negative personal experiences and ethnocentric attitudes.

The studies above dictate the need for teacher education programs to reevaluate their effectiveness in preparing teachers for a multicultural society. Despite their experiences in teacher education programs, many preservice teachers graduate without
fundamentally changing their preexisting beliefs and assumptions toward multicultural science education. These beliefs, and experiences, may prove to be influential factors in the development of high science teacher efficacy beliefs and positive attitudes toward equitable science teaching practices.

Effective Teachers of Diverse Students

In her book, *The Dreamkeepers: Successful Teachers of African American Children*, Gloria Ladson-Billings discusses the characteristics of effective teachers who use culturally relevant pedagogical practices to meet the needs of African American children. These characteristics were developed from her study of a group of eight teachers (5 African American and 3 Caucasian) who were chosen as exemplars of excellence in teaching based on recommendations and testaments of parents and principals. This book uses qualitative methodology to convey a message of pedagogical excellence through a variety of sources, such as descriptive scenarios and vignettes. These vignettes were developed based upon triangulated data gathered from Ladson-Billing’s personal stories and experiences as an African American child, with stories from the field and narrative comments from the eight teachers.

Ladson-Billings (1994) contends that effective teachers are able to distinguish equitable from sameness, thereby using culturally relevant teaching practices to meet the needs of their students. She goes on to say that effective teachers of diverse students possess the following characteristics:

- High self-esteem [confidence] and a high regard for others;
- A belief that all students can succeed;
- See themselves as giving back to the community;
• See teaching as a creative endeavor;

• Help children make connections between their community, national, and global identities;

• Use diverse ways of knowing and learning to “dig knowledge out” of students. They believe that all kids come to school with knowledge and that this knowledge must be explored and utilized to increase student achievement;

• Encourage a community of learners;

• Encourage students to learn collaboratively; and

• Cultivate relationships beyond the classroom (pp. 30-77)

Irvine (2003) contends that effective teachers of diverse students “See with a Cultural Eye.” In her book *Educating Teachers for Diversity*, Irvine argues that although it is important and necessary for teachers to possess content knowledge and pedagogical skills, these qualities are not enough to effectively educate today’s youth. To be an effective teacher of diverse populations, teachers must also be culturally sensitive. Using experiences from her professional development center, CULTURES, which include listening to voices of veteran teachers through reflective journals, projects, lesson plans, and transcripts gathered from entry and exit interviews, along with classroom and school visits, Irvine contends that effective teachers of diverse students:

• Care: They trust and respect students and recognize them as individuals. They set limits, provide structure, have high expectations, and push students to succeed.
• View teaching as mothering: They feel a sense of personal attachment and kinship to diverse students.

• Believe: They believe in teaching and their ability to influence student achievement. They are confident in their ability to teach and persist even when the odds seem against them. They use challenging and creative instructional techniques to meet students’ needs. They believe that all students can learn and thus are resilient, even in the face of obstacles.

• Demand the best: They set high expectations for their students. (pp. 9-12)

Using a combination of information gathered from research, theory, and practice, Gay (2000) examined the characteristics of effective teachers of diverse populations in her book *Culturally Responsive Teaching: Theory, Research & Practice*. Instead of compartmentalizing theory, research, and practice as it relates to the education of diverse students, Gay juxtaposes this information to create a useful and conceptual system of what it means to effectively educate all students, thereby “improving the achievement of ethnically diverse students” (p. xvii). Gay argues that effective teachers are culturally responsive teachers. She defines culturally responsive teaching as:

> using cultural knowledge, prior experiences, frames of reference, and performance styles of ethnically diverse students to make learning encounters more relevant to and effective for them. It teachers *to and through* the strengths of these students (p. 29)

Furthermore, Gay contends that effective teachers validate students’ sociocultural backgrounds. They use diverse ways of knowing and learning to connect academic curricula to students' lived experiences. They build learning communities and personal connections with the students in their classrooms. They develop, simultaneously, academic excellence, social consciousness, cultural competence, and cultural affirmation
within themselves and their students. They cultivate cooperation and collaboration, thereby allowing students to take responsibility for their own learning. This cultivation also facilitates the development of a reciprocal relationship of caring amongst students and between the students and their teachers. Caring is a powerful value and is characterized by “patience, persistence, facilitation, validation, and empowerment for the participants” (p. 47). Gay goes on to state that a higher level of student success is generated by teachers who genuinely care about their students.

Equally important is the fact that effective teachers have faith in themselves and the academic ability of their students. They teach the whole child, intellectually, socially, and emotionally by “using cultural referents to impart knowledge, skills, and attitudes” (p. 382). They empower students to succeed and instill efficacious behaviors in their students. This is done by modeling positive self-efficacy beliefs and celebrating individual and collective achievements.

Atwater (2000) combined the aforementioned characteristics of effectiveness and applied them to the field of science education. Atwater states that within science education, effective teachers are also known as multicultural science teachers. These teachers emphasize the need to provide ethnically diverse students with equitable opportunities to learn quality science. In her review of the literature involving equity and Black Americans, Atwater delineates many of the barriers that are in place which prevent diverse students from reaching high academic standards. Within this article, she also articulates the strengths that diverse students bring into the science classroom. In order to ameliorate the obstinate barriers that continue to disenfranchise diverse youth, effective science teachers must integrate the funds of knowledge (e.g. diverse ways of knowing
and learning and diverse experiences) diverse students bring with them into their pedagogical tool kit. Atwater posits that effective science teachers of diverse students (i.e. multicultural science teachers):

- Give their students opportunities to reason about science, to argue about alternative explanations for their science results, and to test their ideas;
- Make connections between students’ sociocultural backgrounds and science;
- Are effective communicators. They use culturally related ways of communicating, both explicitly and implicitly, to communicate knowledge;
- Have high expectations of student success, regardless of the students’ background;
- Adapt the science resources, e.g. curriculum, to meet the needs of the students;
- Use students’ parents, families, and communities as a resource;
- Acknowledge, accept, and respect student differences;
- Use alternative forms of assessment;
- Strive for equity; and
- Care about their students (pp. 157-169)

Although called by many different names, the studies above show that effective teachers of diverse students facilitate environments where students’ differences are used as building blocks to academic success. The literature reviewed above highlights the need to create a learning community that recognizes and accepts all students. Ladson-
Billings (1994) notes the importance of recognizing differences in race/ethnicity and culture. Similarly, Irvine (2003) underscores the importance of seeing with a cultural eye. Although there are many characteristics effective science teachers possess, the most important one may be that of an empathetic attitude. It is by caring that teachers open their eyes to see differences and use those differences to develop ideological beliefs and pedagogical beliefs that are inclusive of all students. Yet, how can teachers develop any of the abovementioned attitudes if he or she has never been exposed to diversity?

**Self-Efficacy Beliefs**

**Attitudes**

Riggs (1991) contends, “An elementary teacher judges his/her ability to be lacking in science teaching (belief) and consequently develops a dislike for science teaching (attitude). The result is a teacher who avoids teaching science if at all possible (behavior)” (p.5). Most preservice teachers enter teacher education programs with negative beliefs about science teaching and diversity. These beliefs affect their attitude, and subsequently, their instructional practices (Koballa & Crawley, 1985; Pajares, 1992; Bandura, 1997). These attitudes may be a result of many factors (Weiss, 1997). Therefore, the area of self-efficacy deserves considerable attention.

**Bandura’s Theory**

Much of the research that has been done on self-efficacy has been underpinned by Bandura’s social cognitive theory (1977, 1986, 1997). In recent years, self-efficacy beliefs have been noted to be strong indicators of success, or lack thereof, in teaching and learning. Self-efficacy is defined as “beliefs in one’s capabilities to organize and execute the courses of action required to manage prospective situations” (Bandura, 1986, p. 389).
They determine how people feel, think, motivate themselves and behave. Bandura (1986) goes on to say, “among the different aspects of self-knowledge, perhaps none is more influential in people’s everyday lives than conceptions of their personal efficacy” (p. 390).

Bandura (1977, 1986) divided self-efficacy into two cognitive areas, personal efficacy and outcome expectancy. Personal efficacy is defined as “judgments about how well one can organize and execute courses of action required to deal with prospective situations that contain ambiguous, unpredictable, and often stressful elements (Bandura, 1977, p. 201). Outcome expectancy is “a person’s estimate that a given behavior will lead to certain outcomes” (p. 201). Although both personal efficacy and outcome expectancy are measures of self-efficacy, outcome expectancy and personal efficacy differ because a teacher can believe that a specific action will produce certain outcomes, yet not believe that executing this action will influence student behavior. For example, some teachers may believe that a student’s external environment is more influential than effective teaching.

Bandura (1986, 1997) goes on to note that individuals who possess a low sense of self-efficacy have low aspirations, weak commitments to goals, dwell on personal deficiencies, and shy away from difficult tasks. On the other hand, those individuals who possess a strong sense of self-efficacy set challenging goals, while maintaining a strong commitment to them. They face failures and setbacks by redefining their effort. Furthermore, these individuals approach challenging tasks as assignments to be conquered rather than as threats to be avoided. Bandura’s theory of self-efficacy has
been extended to the field of teacher education (Gibson & Dembo, 1984; Tschannen-

**Teacher Efficacy**

A variety of factors may contribute to a teacher’s effectiveness, or ineffectiveness, in the classroom. One of those factors is a teacher’s belief in his/her ability to affect change in students’ academic success, also referred to as teacher efficacy. Teacher efficacy is a future-oriented construct. It has been described as a teacher’s perceived ability to organize and implement the actions needed to bring about desired results (Tschannen-Moran, Woolfolk-Hoy, & Hoy, 1998). Teacher efficacy has been related to student achievement, student motivation, and innovative teaching practices (Gibson & Dembo, 1984; Tschannen-Moran, Woolfolk & Hoy, 1998; Wookfolk & Hoy, 1990). Ashton (1984) argues, “no other teacher characteristic has demonstrated such a consistent relationship to student achievement” (p. 28). Before examining the construct of science teacher efficacy, it is important to first understand the historical conceptualizations underpinning the development of the generalized concept of teacher efficacy.

Using questions that were first introduced in the Rand Corporation’s evaluation of projects that were funded by Title III of the Elementary and Secondary Education Act, Ashton, Webb and Doda (1983) investigated the relationship between teachers’ self-efficacy beliefs and student achievement. Teachers’ self-efficacy levels were based on a five point Likert-type response to the following two questions 1) “When it comes right down to it, teachers really can’t do much because most of a student’s motivation and performance depends on his or her home environment; and 2) If I try really hard, I can get through to even the most difficult or unmotivated students.”
The first question measured outcome expectancy or general teaching efficacy. General teaching efficacy has been defined as “teachers’ expectations that teaching can influence student learning” (Ashton & Webb, 1986, p. 4). Those teachers who agreed with this statement believed that their influence on student learning would be negated by external environmental influences. The second question measured personal teaching efficacy. Those teachers who agreed with this statement believed that they had the ability to reach any student. Based on quantitative and qualitative analyses of data gathered from study participants, Aston, Webb, and Doda (1983) came up with two conclusions. Teachers with high self-efficacy beliefs are more likely to uphold high academic standards, use alternative instructional practices, keep students on-task, and build student-teacher relationships with students they perceive to be low achieving. Conversely, teachers with low self-efficacy beliefs are more likely to group students according to their academic ability, use teacher-centered instructional techniques, lose control over student behavior, and define student behavior as disruptions, especially those students they perceived as low achieving (Ashton, Webb, & Doda, 1983).

Due to criticisms of the two question results based upon the Rand study, Gibson and Dembo (1984) developed a new instrument to measure teacher self-efficacy. Their 30-item Teacher Efficacy Scale was based on Bandura’s social cognitive theory. Using elementary teachers with varying years of teaching experience, qualitative and quantitative findings suggested that those teachers with high self-efficacy had a stronger academic focus, were persistent in their use of questioning, spent less time on off-task instruction, and spent less time using grouping procedures. In summary, Gibson and Dembo (1984) concluded the following: “In applying this theory [Bandura’s] to teachers,
it might be predicted that teachers who believe student achievement can be influenced by effective teaching (outcome expectancy) and who also have confidence in their own teaching abilities (personal efficacy) should persist longer, provide a greater academic focus in the classroom, and exhibit different types of feedback than teachers who have lower expectations concerning their ability to influence student learning” (p. 570). Enochs and Riggs (1990) extended this idea to preservice elementary science teaching noting that the extent to which teachers believed they can influence student learning is important in effective science teaching.

*Science Teaching Efficacy*

Scaffolding off of Bandura’s theory and Gibson and Demo’s Teaching Efficacy Scale, Enochs and Riggs (1990) applied the constructs of personal efficacy and outcome expectancy to the study of preservice science teaching. They predicted that teachers who believed that student learning could be influenced by effective teaching (outcome expectancy) and were confident in their own teaching abilities (personal efficacy) would persist longer, provide increased academic focus in the classroom, and exhibit a repertoire of ideas and strategies as opposed to teachers with low self-efficacy. In order to determine which teachers were most likely to be successful in teaching science (i.e. efficacious teachers), Enochs and Riggs (1990) developed the STEBI-B.

The STEBI-B offers a valid and reliable way to assess the science teacher efficacy beliefs of preservice elementary teachers. A panel of five judges who were familiar with the construct validated the content used in the survey. The reliability for internal consistency reported a Chronbach’s alpha coefficient of 0.90 for the Personal Science Teaching Efficacy Scale (PSTE) and 0.76 for the Science Teaching Outcome Expectancy.
Scale (STOE). Based on the results yielded from the 212 preservice teachers who took the final 23-item survey, Enochs and Riggs (1990) concluded, “Change in teacher behavior is dependent upon attention to the belief systems of teacher themselves. Teacher education programs must be aware of their students’ beliefs and plan for experiences which will have a positive effect on teacher personal self-efficacy and outcome expectancy” (Enochs & Riggs, 1990, p. 701).

In 1995, Enochs, Scharmann, and Riggs decided to investigate the extent to which the amount of science coursework preservice teachers had received was related to their science teaching efficacy. Using the scores obtained from 73 preservice elementary teachers on the Science Teacher Efficacy Beliefs Instrument-B (STEBI-B) and the amount of science these preservice teachers indicated they had received in high school and college, Enochs et al. (1995) found significant correlations between these factors upon data analysis. More specifically, significant correlations ($r = -0.21$, $p = 0.05$) were found between personal science teacher efficacy and the amount of science students received in high school. Similarly, significant correlations ($r = -0.22$, $p = 0.05$) were also found between personal science teacher efficacy and the amount of science these preservice teachers received in college.

The negative relationships that were found upon data analysis indicated that preservice elementary teachers who received more science instruction during their high school and college years showed a decrease in their personal science teacher efficacy. The rationalization put forth by Enochs et al. (1995) to explain these results was based on the method of science delivery. Specifically, they postulated that science courses in high school and college placed an increased emphasis on the fact-based transmission of
knowledge from the teacher to the student, with a heavy focus placed on memorization. This method of transmission is antithetic to the way preservice elementary teachers are instructed to deliver scientific knowledge in their methods courses. Thus, according to Enochs et al. (1995), vicarious experiences, i.e. watching the way their science teachers transmitted knowledge, played a vital role in the development of these preservice teachers’ negative beliefs about their ability to be effective science teachers.

In a large part, increased levels of education tend to be associated with higher levels of self-efficacy (Fives, 2003; Morrell & Carroll, 2003). However, as demonstrated by Enochs et al. (1995), it is very important to recognize that there are a multitude of factors embedded in educational experiences that affect an individual’s confidence. Thus, vicarious experiences represent only one source from which teachers gain, or lose, teacher efficacy (see Figure 5).
Bandura (1997) postulated that there are four sources that may influence an individual’s self-efficacy beliefs: mastery experiences, vicarious experiences, physiological and emotional cues, and verbal persuasion. Mastery experiences, if presented appropriately, are considered to have the most powerful impact on self-efficacy (Bandura, 1997). Therefore, numerous studies have been conducted to document the effects of methods courses and field experiences on preservice teachers’ self-efficacy beliefs about science teaching.

Weaver, Hounshell, and Coble (1979) conducted a study to determine the effects of science methods courses, with and without field experiences, on the attitudes of 80 preservice elementary teachers at East Carolina University. These students were enrolled
in “Teaching Science in the Elementary School” during the winter quarter of 1996-1997. Every student in the study had completed five college science content courses. Students were randomly assigned to one of two groups. The first group of students received instruction at the university with no field experiences, while the second group of students received instruction at the university in addition to field experiences at a local public school as part of their course requirement. When teaching lessons both groups were allotted 20 minutes to assemble their materials, 25 minutes to teach their lesson, and 20 minutes at the completion of the lesson to critique the experience.

Quantitative data was collected using the Science Attitude Scale for Preservice Elementary Teachers, the Science Teaching Attitude Scale, the Sixteen Personality Factor Questionnaire, and the Rokeach Dogmatism Scale Form E. Qualitative data was collected using informal questionnaires and 15-minute interviews. Quantitative data analysis showed that field experiences did not have a significant effect on preservice teachers’ attitudes toward teaching science. However, qualitative data supported the value of early field experiences on the attitudes of preservice teachers. Students participating in the field experiences expressed attitudes of confidence about their potential performance in the classroom in regard to teaching science.

Plourde (2002) investigated the impact of student teaching on preservice elementary teachers’ science teaching efficacy. Participants in this study consisted of three cohorts of preservice elementary teachers, totaling 59 teachers, at a large university in the Western United States. Quantitative data was gathered from the STEBI-B, using a pretest-posttest one-group design prior to and after the student teaching semester. A t-test was run to determine if there was a significant difference between the means of the
pretest and posttest scores. Involvement in student teaching did not appear to have a significant effect on the students’ sense of personal science teaching efficacy (PSTE). The PSTE scores changed from 49.29 to 50.15, an increase of .86, which suggests no statistically significant difference. This lack of significance was attributed to the fact that preservice teachers’ beliefs and attitudes were firmly embedded prior to entering their science methods course. However, there was a significant change in science teaching outcome expectancy beliefs (STOE). The STOE scores decreased from 36.14 to 33.93, a decrease of 2.21. A possible explanation put forth by the researcher for the statistical significance between the mean difference scores on the STOE subscale was that student teaching may have deteriorated the confidence of these student teachers. More specifically, it was asserted that specific experiences within the school setting (e.g. time constraints, lack of materials and supplies, lack of collegial support, and classroom management issues) contributed to this deterioration. However, due to the use of a pretest-posttest one-group design, there are many threats to the internal validity of this research study which have not been taken into account. Results would be strengthened with the addition of a control group. Therefore caution must be taken when generalizing the results obtained from this study.

Morrell and Carroll (2003) researched the effect of programmatic factors, such as science methods courses, student teaching, and science content courses, on the science teaching efficacy beliefs of preservice elementary teachers. This investigation was conducted at a small liberal arts private university in an urban setting. Preservice teachers are required to spend 3 hours a week in a classroom during their freshman year, 6 hours during their junior year, and twelve hours a week during their senior year. They
must also take 9 semester credit hours of science content (Human Biology, Ideas in
Physics, and Introductory Earth Science) and one 3-credit hour elementary mathematics
and science teaching methods course. In their methods course, most pedagogical ideas
are modeled and include active participation by the students. They are also guided
through a variety of inquiry-based science and mathematics activities with follow-up
discussions.

Science content courses met in the Fall of 1998 and 1999. Study participants
from this program consisted of 5 sophomores in Human Biology, 20 mostly sophomores
in Ideas in Physics, and 21 freshman and sophomores in Introductory Earth Science. The
methods courses were held in the Fall of each year from 1997 to 2000. There were 25,
16, 22, and 35 students enrolled in these courses, respectively. Student teachers were
surveyed in the Spring of 2001. There were 29 participants in this group. There were a
total of 399 responses collected. However, only 342 had matching pre/post surveys
appropriate for analysis due to student absences. Paired t-tests were run on the pre and
post-survey scores for each course. Those students enrolled in the science content
courses and student teaching course showed no significant changes in the PSTE scores or
STOE scores. However, statistically significant differences were found for those enrolled
in the science methods courses.

Although not specifically related to science teaching efficacy, Woolfolk Hoy and
Burke Spero (2005) investigated changes in teacher efficacy experienced by elementary
teachers during the early years of teaching. This longitudinal investigation explored
teacher efficacy for both preservice teachers and novice teachers. For the purposes of
this study, only the findings from preservice teachers will be discussed; that is
information gathered from beginning of the teacher preparation program to the end of
student teaching. The participants in this study were a cohort of 53 preservice teachers in
a Master’s of Education initial teaching certification program who began taking courses
during 1997-1998. In order to measure changes in teaching efficacy, preservice teachers
were asked to complete the Gibson & Dembo Short Form and the Bandura Teaching
Efficacy Scale at three different phases: during the first quarter of their teacher
preparation program before completing the majority of course work, at the end of their
student teaching semester, and at the end of their first year of actual teaching. Changes in
teaching efficacy were analyzed with a repeated measures analysis for each instrument.

Findings revealed statistically significant changes in efficacy scores, on both the
Personal Teaching Efficacy (PTE) and General Teaching Efficacy (GTE) subscales, for
both instruments. The PTE subscale is analogous the Personal Science Teaching
Efficacy (PSTE) subscale, while the GTE is analogous to the Science Teaching Outcome
Expectancy (STOE) subscale (Enochs & Riggs, 1990). Teaching efficacy increased
during teacher preparation and student teaching. However, because a pretest-posttest
design was not utilized, it is unclear whether these changes were a result of individual or
collective factors. In other words, it is unclear if these significant effects were a result of
the course work taken during preservice teachers’ preparation program, their student
teaching experiences, or whether the observed effects were an outcome of the
combination of course work and student teaching.

Most of the studies above investigated the influence of mastery experiences, such
as methods courses and field experiences, on preservice teachers’ science teaching
efficacy beliefs. However, these studies have not accounted for other factors, such as
teachers’ beliefs about diversity and multiculturalism, which may affect science teaching self-efficacy. Additional research needs to be conducted on the effects of mastery experiences on the self-efficacy beliefs of preservice elementary teachers about equitable science teaching and learning.

_Science Teaching Efficacy and Diversity_

Although self-efficacy beliefs may be influenced by Bandura’s four sources, they may also be influenced by a variety of sociocultural factors (e.g., socioeconomic status, race, language, ethnicity, and culture) (Atwater, 1996; Gomez & Tabachnick, 1992; Lee, 1999; Rodriguez, 1998b; Stegemiller, 1989; Yerrick & Hoving, 2003). Researchers have documented the negative beliefs and attitudes preservice teachers have toward multicultural science teaching (Atwater, 1996; Rodriguez, 1998b). Cognizant of the additional factors that may affect self-efficacy beliefs, Ritter, Boone and Rubba (2001) developed an instrument to measure the self-efficacy beliefs of preservice elementary teachers regarding science teaching and learning for diverse populations.

Scaffolding off of the work on self-efficacy beliefs from Bandura (1977, 1986, 1997) and Enochs and Riggs (1991), Ritter et al. (2001) developed the Self-Efficacy Beliefs about Equitable Science Teaching and Learning (SEBEST) instrument to measure the personal science teaching efficacy (PSTE) and science teaching outcome expectancy (STOE) beliefs of preservice elementary teachers regarding science teaching and learning for diverse populations. Using survey data collected from 213 prospective elementary teachers, the reliability for the entire scale was determined to be 0.87. Specifically, the reliabilities for PSTE and STOE were 0.83 and 0.78, respectively. Similarly, the construct validity, determined from Rasch item analyses, was 0.81 for the STOE subscale.
Based upon the validity and reliability statistics, the SEBEST seems to be a “content and construct valid instrument, with high internal reliability qualities, for use with prospective elementary teachers to assess self-efficacy beliefs for teaching and learning for diverse learners” (Ritter et al., 2001, p. 188). Besides Ritter et al., no research has been done using this instrument with preservice elementary teachers. However, Wade (1995) conducted a qualitative study examining the effects of service-learning on preservice teachers’ self-efficacy when service-learning projects are situated in an urban community.

Wade (1995) investigated the effect of service-learning on the self-efficacy beliefs of 41 preservice elementary teachers enrolled in a social studies methods course. All of the preservice teachers were white, with only one male in the group. They were either in their junior or senior year of undergraduate work. Students completed a service-learning project that focused on meeting a need in the community or school. Therefore, projects ranged from cleaning up a local park to working with disadvantaged youth. Multiple sources were used to generate data, including journal entries and students’ papers. Students completed a “semantic differential on ‘being active in the community’” (Conrad and Hedin 1981) at the beginning and end of the course” (p. 124). Open-ended interviews were used and focused on their previous experiences with service learning, their present experiences, and what they were learning about their beliefs, others, and serving the community. In addition, interviews and practicum evaluations by school teachers and school children’s written comments were used to triangulate the collected data.
Data analysis revealed that the majority of participants reported that service-learning had a positive effect on their self-efficacy. Furthermore, 16 students reported that their views toward teaching had changed as a result of participating in the service-learning experiences. For example, a student who worked with disadvantaged children stated, “It also reinforced my decision to become a teacher, not only to teach our youth but also to give them the courage to believe in themselves and go after their dream.” Some of the students discussed how important it was for teachers to understand the home lives of children if they wanted to be effective in their instructional practices. A deeper understanding of students’ reactions to service-learning was revealed during the interviews. Based on their service-learning experience, one student surmised, “Teaching doesn’t just include teaching the basics—reading, writing, arithmetic. I mean, you have to be friend and nurse sometimes…So many other roles you have to play besides the teacher role.” (p. 125).

Based on her findings, Wade concluded carefully planned experiential learning experiences, which include opportunities for guided reflections are powerful factors in the professional development of preservice teachers. In addition, service-learning may have the potential to overcome the ill-preparedness some preservice teachers explicate after participating in methods courses. Furthermore, “the preservice period appears to be a viable time to introduce service-learning to future teachers” (127) of diverse populations.

Service Learning and Multicultural Science Teaching

Field experiences have been shown to influence preservice teachers’ beliefs about diversity (Boyle-Baise, 2002). When combined with a service-learning component, field
experiences offer preservice teachers and community members an opportunity to collaborate on meeting the educational needs of the community’s youth (Wade, 2000). Community-based service-learning, which falls under the broader umbrella of service learning, is a student-centered pedagogy that connects authentic, meaningful service with academic study (Eyler & Giles, 1999). It has also been defined as “an experiential form of learning in which future teachers work with and learn from local communities” (Boyle-Baise, 2002, p. xi). Boyle-Baise (2002) asserts that “when community-based service learning is located in and responsive to culturally diverse and low-income communities, it can connect future teachers with constituents for multicultural education, alert them to family and community resources for teaching, and help them to understand educational concerns of their future students” (p. xi).

In a literature review on service-learning and multicultural teacher education, Wade (2000) noted that there are at least four reasons to include service-learning in the effective preparation of preservice teachers for a multicultural population. The first is that service-learning positively affects students’ academic skills, problem-solving abilities, higher-order thinking skills, and efficacy. In addition, the reciprocal nature of authentic, quality service-learning experiences allow preservice teachers to be seen as giving back to children and community members, instead of “using” the school or community as springboard for their own learning. Second, service-learning experiences contribute to an individual’s social/emotional growth. For example, students participating in service-learning develop “student-sensitive curricula and instructional tools, while establishing caring relationships with students” (Wade, 2000, p.22). Third, service-learning in diverse schools and community settings enhance preservice teachers’
reflection skills. Preservice teachers learn to examine and question their preconceived notions of effective pedagogical practices, stereotypes, and/or prejudices. In addition, preservice teachers begin to set high expectations for students of color. Finally, preservice teachers learn how to teach the “whole” child. In other words, they learn that their role is not just that of a teacher. In many instances, teachers are expected to be social workers, role models, and community leaders.

Community-based service-learning experiences have also been documented to have a positive effect on preservice teachers’ beliefs about equitable science teaching, commonly referred to as multicultural science teaching (Calabrese Barton, 2000). This assertion is highlighted in Calabrese Barton’s (2000) study, “Crafting multicultural science education with preservice teachers through service-learning.”

Calabrese Barton (2000) studied the transformation of 24 preservice science teachers’ views of multicultural science education through community-based service-learning at a homeless shelter. The study took place over the course of three semesters during the 1996-1998 academic years. The ages of the preservice science teachers ranged from 21 to 33. They were either full or part-time students enrolled in a preservice program in secondary science education. Their racial and ethnic backgrounds varied. Data collection procedures consisted of hour-long focus group conversations. The questions asked during these conversations focused on teaching in diverse settings, and in particular, settings where class, race, and ethnicity were either diverse, or outside of the norms of mainstream America. Outside of the norms meant either high levels of poverty, 100% Hispanic, or 100% African American. Preservice teachers were also interviewed, individually, 2 out of 3 semesters, before the start, and at the end, of their service-
learning experience. Interviews lasted approximately 30-40 minutes and were used to
address issues that were raised in the focus group discussions. Additional data was
collected in the form of journal entries, observations, and field notes.

Calabrese Barton had weekly planning and reflection meetings that were meant to
challenge preconceived beliefs about teaching and to create alternative possibilities for
multicultural science education as a content and pedagogy in science classes. Ideas
involving issues related to multiculturalism were explored in two ways. First, they were
reflected upon, discussed, deconstructed, and reconstructed. Next, these ideas were
enacted through collaborative lesson planning and implemented with the children at a
neighborhood homeless shelter.

Initial interviews indicated that preservice teachers entered the service-learning
experience with preconceived notions about teaching and multiculturalism. However,
once they began teaching science at the shelter, these teachers began to question their
own beliefs and attitudes regarding homeless children, schooling, science, pedagogy, the
community, and world views (Western). They also began to articulate new ideas and
challenges in three areas: challenging the ‘culture’ in ‘multicultural’ through content and
pedagogy; the place of uncertainty in connecting theory with practice; and connections
between multicultural science education and social and political issues (Calabrese Barton,
2000, p. 805). Theresa, one of the preservice teachers, wanted to challenge culture by
valuing the experiences students brought to science class, or an after-school program,
even when those experiences weren’t indicative of Western knowledge. Mark, another
preservice teacher, agreed with Theresa by saying:

The differences between my teaching at the shelter and at school are clear. At
the shelter we try to account for the different ways of knowing science, the ways
our students come to know science and to try to construct an inclusive teaching practice by insisting that everyone participates, that everyone counts equally…The activities at the shelter take into account the children, their needs. Many other programmes do not consider the different ways of knowing science, the different ways our students come to know science, and the construction of an inclusive teaching practice (p. 807).

The idea of uncertainty in connecting theories with practice was displayed when teachers began to question their knowledge base and resulting behaviors. They began to question what they knew and the implications this had for children and for their own sense of self. A connection between multicultural science education and politics was made when preservice teachers started to question issues such as power, control, and school politics. Theresa voiced the following:

In the future my pedagogical practices will echo with many of the beliefs of bell hooks…I will focus on the fact that all my students have an invaluable voice that must be heard in some form. I wrestle with the issue of power, however, because I am terrified to lose control. Yet, I am coming intellectually closer with a safe and healthy balance of free dialectal exchange without losing authority (p. 812).

Based upon her findings, Calabrese Barton (2000) concluded that the preservice teachers enacted visions of multicultural science education. Furthermore, Calabrese Barton asserts that service-learning can be used as a tool to help students redefine and challenge their beliefs in three ways: 1) by allowing opportunities to reflect on science teaching and students separate from schooling, therefore separating their perceived expectations of students, schooling and themselves; 2) by allowing preservice teachers an opportunity to work with children in an informal setting, connecting theory with practice; and 3) by facilitating metacognitive development.

In science education, Calabrese Barton (2000) is the only researcher who has investigated the effects of service-learning on preservice science teachers’ beliefs about multicultural science education. This one study focused on the beliefs of preservice
secondary science teachers. Therefore, it would be beneficial to research the effects of service-learning on preservice elementary teachers’ beliefs about issues of multiculturalism in science teaching.

Summary

Reform documents (AAAS, 1989; NRC, 1996; NSTA, 2003) and science educators (Atwater, 1996; Calabrese Barton, 2000; Lee, 1999; Rodriguez, 1998b; Yerrick & Hoving, 2003) alike believe that all children, regardless of their background, deserve equitable access to challenging and meaningful learning experiences in science education. However, the success of “science for all” depends on the attitudes and beliefs preservice teachers possess about equitable science teaching and their ability to be effective science teachers, regardless of students’ sociocultural background.

Many important points emerge from the literature. The first is that the most powerful influence on student learning and achievement, and ultimately the production of a scientifically literate population, is the science teacher. Yet, numerous teachers continue to respond in ways that inadequately address the call of “science for all.” Paige (2001) underscores this point with the following announcement, “America needs inventors, engineers, doctors, computer designers and scientists. We need botanists, veterinarians, chemists, astronomers, and naturalists. But in order to pursue these careers, our children need an excellent grounding in science and right now our system is not delivering it…We need to help students of every race perform better.”

Second, preparing preservice teachers to effectively teach science to diverse populations is a critical issue facing teacher education programs. Compatibility between school culture (teacher and curriculum) and student culture facilitate effective
communication patterns and positive relations (Hilliard, 1992; Irvine, 1992). However, because many teachers, preservice and inservice, who are white, monolingual, and middle-class, possess negative beliefs and attitudes toward inclusive teaching practices and diverse student groups (Banks, 2002), communication patterns and academic learning are interrupted (Hilliard, 1992; Irvine, 1992). These views coupled with differential teacher expectations for diverse student groups and lower teacher self-efficacy beliefs contribute to the endemic academic failure patterns of minority and low-income students in science education. Consequently, Delpit (1995) argues, “If we are to successfully educate all of our students, we must work to remove the blinders of stereotypes, monocultural methodologies, ignorance, social distance…and racism. We must work to destroy those blinders so that it is possible to really see, to really know the students we must teach” (p. 182).

Third, the disparity that exists between the sociocultural backgrounds of teachers and students dictates the need for teachers to develop “sociocultural consciousness” (Villegas & Lucas, 2002); that is, teachers must understand that factors such as race/ethnicity, language, class, and culture influence people’s ways of thinking and behaving (Banks, 2002; Villegas & Lucas, 2002). Furthermore, in order to understand their students, teachers must first understand, and critically examine, their own beliefs about diversity. Equally important is the need for preservice teachers to critically analyze the interconnectedness of their beliefs about diversity and equitable science teaching.

Finally, many science teachers are not reaching all of their students with equal efficacy (Gilbert & Yerrick, 2001). Since teaching efficacy beliefs have been documented to be good predictors of behavior (Ashton & Webb, 1986, Bandura, 1986,
Enochs & Riggs, 1990). Researching factors that affect the development of self-efficacy beliefs, teacher attitudes and teaching practices may be important to the scientific community (Pajares, 1992; Richardson, 1996) (see Figure 6). Pajares (1992) underscores this point by stating, “teacher educators should continue to explore how teacher efficacy develops, what factors contribute to strong positive teaching efficacy in varied domains, and how teacher education programs can help preservice teachers develop high teacher efficacy” (p. 577). If teachers’ beliefs about equitable science teaching and learning are contradictory to reform recommendations, “science for all” may be doomed for failure.

Figure 6. Factors affecting Science Teaching Efficacy

In science education, researchers have studied the effect of field experiences on preservice teachers’ science teaching efficacy (Morrell & Caroll, 2003; Plourde, 2002). However, no study has documented the effect of field experiences on preservice teachers’ self efficacy beliefs about equitable science teaching and learning. In addition, there has
been little research in identifying science teacher education practices that maximize the development of preservice elementary teachers’ self-efficacy beliefs, while challenging their preexisting beliefs in regard to teaching science for diversity (Calabrese Barton, 2000; Rodriguez, 1998b; Yerrick & Hoving, 2003).

Service-learning has been viewed as a powerful pedagogical alternative that promotes the development of competent and effective citizens by combining academic instruction with the opportunity to practice democratic citizenship while engaged in service to the community (Billig & Furco, 2002). Studies of service-learning confirm its positive effects on preservice teachers’ self-efficacy (Wade, 1995). In addition, Calabrese Barton (2000) and Wade (1995, 2000) have documented the positive changes in preservice teachers’ attitudes toward multicultural teaching. The preservice teachers who participated in Calabrese Barton’s study became more cognizant of the need to incorporate children’s lived experiences into their curriculum and adjust their instructional practices accordingly.

Providing experiences that positively affect preservice teachers’ beliefs about equitable science teaching and learning will foster the development of essential knowledge, skills, beliefs, attitudes and behaviors necessary to work with students from diverse sociocultural backgrounds. Darling-Hamond, Wise, and Klein (1999) underscore this point by stating, “If all children are to be effectively taught, teachers must be prepared to address the substantial diversity in experiences students bring with them to school -- languages, cultures, home conditions, learning styles, exceptionalities, abilities, and intelligences” (p. 2). Thus, the present study investigated the effects of infusing a community-based service-learning component into a science methods curriculum.
CHAPTER THREE: METHODS

Introduction

Given the fact that elementary school is usually the first place most children experience science teaching, and our school-aged population is becoming increasingly diverse, it is important to understand the beliefs that preservice elementary teachers possess about equitable science teaching and learning. Equally important is the need for teacher education programs to identify teacher education practices that may help preservice elementary teachers develop positive beliefs and attitudes about diversity and science teaching. As Czerniak and Chiarelott (1990) contend, “strategies that reduce anxiety and increase efficacy are worthy of attention in teacher education if we wish to improve the quality, quantity, and success of science curriculum and instruction” (p. 55).

Using Bandura’s social cognitive theory of efficacy beliefs as a theoretical framework, this study aims to explore the effects of community-based service-learning on the self-efficacy beliefs of preservice elementary teachers regarding equitable science teaching and learning. It is important to study changes in beliefs at the early stages of teachers’ professional careers because the beliefs of preservice teachers may be amenable to change as opposed to veteran teachers (Richard, 1996). The investigator used a mixed-methods approach to explore this issue which is consistent with the current research methodology used to explore multiculturalism (Calabrese Barton, 2000, Rodriguez, 1998b) and science teaching efficacy (Enochs & Riggs, 1990; Ramey-Gassert, Shroyer,
Staver, 1996) (see Figure 7). The remainder of this chapter will review the research questions that guide the investigation and discuss the research design. Issues related to the research design including the target population and sampling, context of study, data collection, and data analysis will also be discussed.
Figure 7. Main Study Features

Factors affecting Beliefs about Equity and Science Teaching

Community-Based Instruction with an embedded service-learning component

University-Based Instruction

Assessed by

Quantitative Methodology

SEBEST Instrument

Factorial Repeated-Measures ANOVA

Qualitative Methodology

Course Observations

Semi-Structured Interviews

Questionnaires

Constant Comparative Analysis

Generates

Generates

Findings describing and interpreting the effects of community-based and university-based instruction
Figure 7. Main Study Features (Continued)

Timeline

Week 1: Obtained informed consent, Distributed and collected Pre-Questionnaire and SEBEST (pretest) for all sections

Weeks 2 & 3: Conducted Pre-Interviews

Course observations were ongoing throughout the semester

Week 14: Distributed and collected Post-Questionnaire and SEBEST (posttest) for Section 3, Conducted Post-Interviews

Week 15: Distributed and collected Post-Questionnaire and SEBEST (posttest) for Sections 1 and 2, Conducted Post-Interviews
Research Questions

RQ1. In what ways, if any, are the perceptions of preservice elementary teachers enrolled in a community-based science methods course with an embedded service-learning component different from those enrolled in two university-based science methods courses without a service-learning component with respect to their ideas concerning the characteristics of effective science teachers?

RQ2. What is the difference in the Personal Science Teaching Efficacy (PSTE) scores, and Science Teaching Outcome Expectancy (STOE) scores, among preservice elementary teachers enrolled in a community-based science methods course with an embedded service-learning component and those enrolled in two university-based science methods courses without an embedded service-learning component?

RQ3. What science methods course experiences, if any, are identified by preservice elementary teachers as having a positive effect on their science teaching efficacy beliefs concerning equitable science teaching?

RQ4. How do preservice elementary teachers’ beliefs about multicultural science teaching change, if at all, over the course of a semester?

Research Design

In order to answer the research questions posed, both qualitative (questions 1, 3, 4) and quantitative (question 2) methods were employed. Questions one, three, and four were examined using semi-structured interviews, passive observations, and questionnaires. Question two was investigated using a quasi-experimental design which allows investigators to use between-group comparisons (Borg & Gall, 1989). Preservice
elementary teachers, registered in three sections of SCE 4310, received a pretest and posttest.

**Target Population and Sampling**

The target population for this study was preservice elementary teachers. The sampling population encompassed preservice elementary teachers registered in three sections of SCE 4310, *Teaching Elementary School Science*, SCE 4310.001 (Section one), SCE 4310.002 (Section two), and SCE 4310.003 (Section three), during the Spring semester of 2006. Section one was housed at a neighborhood community center which had an embedded service-learning component. Sections two and three were housed at the university with no service-learning component. Sections one and two were taught by the same methods instructor. Section three was taught by a different methods instructor. Because participants self-register for science methods courses, convenience sampling was utilized. Seventy-five preservice teachers from sections one, two, and three consented to take part in the research study: 26, 26, and 23, respectively.

Participants were asked to complete a demographic questionnaire at the beginning of the semester. This questionnaire elicited the following information: student age, race/ethnicity, gender, language, socioeconomic background, undergraduate/graduate level, and current view of their ability to teach science. The demographics for each section are presented in Table 1.
Table 1.
Demographics of Participants

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<td>21</td>
<td>18</td>
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<tr>
<td>Latino/a</td>
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<td>2</td>
<td>3</td>
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<tr>
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<td>24</td>
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<tr>
<td>Percentage</td>
<td>77%</td>
<td>92%</td>
<td>87%</td>
</tr>
<tr>
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<td>6</td>
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<tr>
<td>Percentage</td>
<td>42%</td>
<td>77%</td>
<td>74%</td>
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Course demographics indicated that the sections were fairly homogenous. The majority of the participants were female, with 24 females in Section one, 24 females in Section two, and 20 females in Section three. The majority of participants were also
Caucasian, 77% in Section one, 80% in Section two, and 78% in Section three. The remainder of the participants indicated that their ethnic heritage was African American, Asian/Pacific Islander, Latino/a, or “Other.”

The majority of participants classified themselves as middle class. In Section one, 23% classified themselves as working class, 69% middle class, and 4% upper class. In Section two, 13% classified themselves as working class, 73% middle class, and 4% upper class. In Section three, 48% classified themselves as working class and 52% middle class.

The majority of participants were between the 18 and 21 years of age. However, Section one had more participants between the ages of 22 and 28 (50%). The students’ undergraduate level was proportionate to their age. In Section one, 42% were juniors, 54% were seniors, and 4% were graduate students. In Section two, 77% were juniors, 23% were seniors, and there were no graduate students. Similarly, in Section three, 74% were juniors, 26% were juniors, and there were no graduate students.

Concurrently, participants were asked to complete the 34-item Self-Efficacy Beliefs about Equitable Science Teaching Instrument (SEBEST) (Ritter et al., 2001). At the end of the semester, participants were asked to complete the survey again, along with a questionnaire to determine what relationship, if any, existed between specific course experiences and preservice elementary teachers’ perceived ability about teaching science to diverse student groups.

All participants were invited to participate in personal interviews. However, many preservice teachers were unable to participate because their course schedule and allotted interview times conflicted. Twenty-one preservice teachers participated in the
pre-interviews. Out of the twenty-one pre-interview participants, stratified purposeful sampling, based on race/ethnicity and gender, was used to select fifteen preservice teachers for post-interviews. However, due to scheduling conflicts, only twelve of the fifteen were able to participate in post-interviews. The demographics of interview participants are presented in Table 2.

Table 2. Interview Participant Characteristics.

<table>
<thead>
<tr>
<th>Interview Participants</th>
<th>Ethnicity</th>
<th>Gender</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Section 1</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Erika</td>
<td>African American</td>
<td>F</td>
</tr>
<tr>
<td>Jason</td>
<td>Caucasian</td>
<td>M</td>
</tr>
<tr>
<td>Maria</td>
<td>Latina</td>
<td>F</td>
</tr>
<tr>
<td>Sarah</td>
<td>Caucasian</td>
<td>F</td>
</tr>
<tr>
<td><strong>Section 2</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Angel</td>
<td>African American</td>
<td>F</td>
</tr>
<tr>
<td>Natalia</td>
<td>Latina</td>
<td>F</td>
</tr>
<tr>
<td>Laura</td>
<td>Other</td>
<td>F</td>
</tr>
<tr>
<td>Kim</td>
<td>Caucasian</td>
<td>F</td>
</tr>
<tr>
<td><strong>Section 3</strong></td>
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<td>Michael</td>
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<td>M</td>
</tr>
<tr>
<td>Kathy</td>
<td>Caucasian</td>
<td>F</td>
</tr>
<tr>
<td>Robin</td>
<td>Caucasian</td>
<td>F</td>
</tr>
</tbody>
</table>

Note. "Pseudonyms are used to preserve anonymity"
Context of Study

The University

The university is a metropolitan, Research 1, public university located in the southeastern United States. With four campuses, it is the second largest university in the southeast. In 2004, its total student enrollment was 42,950. One quarter of the student population was African American, Hispanic, Asian, and Native-American. This figure was similar to those diverse ethnic groups, approximately 22%, enrolled in the College of Education.

The university has one of the largest metropolitan colleges of education in the nation. It provides student teachers to public schools throughout the southeast region. The College of Education’s mission is to contribute to the improvement and reinvention of public schooling by preparing teachers, specialized practitioners, administrators, and researchers. In addition, it seeks to provide challenging and supportive learning environments and develop collaborative relationships with the surrounding community.

Methods Courses

Participants were enrolled in a teacher education program in the southeastern United States. Before entrance into the program, students are required to take 10 credit hours of Natural Sciences and 9 credit hours of pre-education courses. Included within these 9 hours is one diversity course, Teaching Diverse Populations. After admission into the College of Education, preservice elementary teachers are required to take one science methods course before exiting their teacher education program. The three science methods courses used in this study met in the Spring of 2006 for sixteen weeks. Section one was housed at a neighborhood community center. Sections two and three
were housed at the university. The elementary science methods courses, in general, were designed to introduce preservice teachers to how children learn science and why science is important.

Section one. Preservice teachers enrolled in section one met at a neighborhood community center every week during their scheduled course time. The 50,000 square foot community center complex contains offices, classrooms, a fitness center, a multipurpose gymnasium, an auditorium with stage, music and art studios, computer labs, and daycare facilities. As one enters the main entrance of the community center, one is captivated by a gallery that showcases the innovative work of children involved in the performing arts programs. The students’ exhibits range from paintings to pottery.

As preservice teachers approached the gallery, they turned and entered the classroom named Friendship Hall. This is where their instruction took place. The instructor, who will be referred to as Instructor Roberts, arrived early to make sure that eight rectangular tables were arranged in a u-shape. Three to four preservice teachers sat at each table. This arrangement allowed Instructor Roberts, who mainly stood or walked around during instruction, to make eye contact and engage the preservice teachers in conversations. The agenda for the day was always displayed on the white board, which was located at the front of the classroom. Each class session began with a welcoming message by the instructor. For example, preservice teachers might have walked into the classroom seeing the phrase “I’m glad to see you” scribbled on the white board. Instructor Roberts then took approximately 10 minutes to “reflect on reflections.” She used this time to talk about the successes some preservice teachers experienced with the lessons they implemented the previous week. She also used this time to address some of
the concerns and questions raised by teachers in their reflections. The next 45 minutes were used to discuss the assigned reading and/or activity for that day. Weekly reading assignments ranged from articles that discussed the nature of science to diversity articles, such as Lisa Delpit’s (1995) article, *The Silenced Dialogue: Power and Pedagogy in Educating Other People’s Children*. Three course sessions were used to explicitly address issues related to diversity. However, one of the discussions on diversity was not embraced (discussed further in Chapter 4). Diversity issues were also explicitly addressed with the following activities, assignments and discussions:

- **The Draw-A-Scientist Test (DAST):** Students drew what they thought a scientist looked like and the reasons behind those depictions.
- **Multicultural Awareness Quiz:** A quiz which often illustrates how an individual’s perceptions of reality and what is actually fact are often in conflict. (see Appendix H)
- **Autobiographical Narrative Assignment:** Students wrote about how aspects of their identity (e.g. race, ethnicity, culture, class) may affect their teaching.
- **Howard Gardner’s Multiple Intelligences and their use in the science classroom**
- **Discussion Board Questions:** Students responded to the following questions:
  - One of the goals for scientific literacy is that all students, regardless of gender, cultural or ethnic background, physical or learning disabilities, aspiration, or interest and motivation in science should have the opportunity to attain higher levels of scientific literacy than they currently do (NRC, 1996, p. 6). What is your view of this goal?
  - What does multicultural science education mean to you?
Racially/ethnically diverse minorities and women remain underrepresented in science related fields. Why do you think this is?

Class discussions were then followed by a 15 minute break, a 45 minute “tutoring” session between preservice teachers and their elementary school students, and a 15 – 20 minute debriefing session to discuss the day’s activities. Debriefing discussions ranged from science activities gone wrong to how to handle students who were disconnected from the science activities chosen by the preservice teachers.

The embedded service-learning component of the course provided preservice elementary teachers with an opportunity to connect theory to practice. In addition, this component benefited the neighborhood by allowing their children an opportunity to become scientifically literate. Preservice teachers worked directly with the children, usually on a 3 to 5 basis (3 preservice teachers and 5 elementary school students), for approximately 45 minutes a week. However, due to attrition rates and absences, this consistency was not always possible. The grade level of the elementary students assigned to preservice teacher teams was consistent. That is to say, 2nd graders were assigned to one team, 3rd graders were assigned to another team, 4th graders were assigned to another team, and 5th graders were assigned to another team. If this coupling procedure was not possible, Instructor Roberts tried to keep the elementary students within one grade level of each other.

Preservice teachers incorporated the 5E approach (Engage, Explore, Explain, Elaborate, and Evaluate) within their inquiry-based science activities to promote the development of critical thinking skills, problem-solving skills, and connections between the children’s lived experiences and science. The community center provided two
classrooms for preservice teachers to conduct inquiry-based activities. However, most preservice teachers preferred to take their students outside to work in the patio area because it allowed groups to spread out as opposed to being confined to a desk/table in the classroom.

Section two. Preservice teachers enrolled in section two met at the university’s main campus in a classroom located on the third floor of the education building. This section was also taught by Instructor Roberts. However, this section did not have an embedded service-learning component.

As preservice teachers entered the classroom, music (usually instrumental) would be playing in the background. This music signaled to students that it was time to begin “bell work.” The bell work was on a desk that was located on the front, right side of the classroom and was usually picked up as teachers entered the room. The purpose of the bell work was to review science concepts learned from the previous week’s activities, which were either implemented by Instructor Roberts or the preservice teachers who taught their “mini-lesson” the preceding week. The mini-lesson was on a science topic chosen by the group. It was an inquiry-based lesson that followed the 5E format. Teaching mini-lessons provided preservice teachers with an opportunity to refine and demonstrate their inquiry teaching skills. In addition, Instructor Roberts indicated that the bell work provided opportunities for preservice teachers to experience and evaluate what they have been taught to think of as good teaching for themselves. After the bell work was completed and reviewed, which usually took approximately 10 minutes, it was time for Instructor Roberts to reflect upon the reflections.
After Instructor Roberts discussed the insights gained by some of the preservice teachers from the previous week’s activities and/or conversations, 45 minutes to an hour were spent engaging preservice teachers in a discursive dialogue about the assigned reading for that week. Like section one, weekly reading assignments ranged from articles that discussed the nature of science to diversity articles, such as Lisa Delpit’s (1995) article, *The Silenced Dialogue: Power and Pedagogy in Educating Other People’s Children*. As with section one, three course sessions were used to explicitly address issues related to diversity. However, unlike those enrolled in section one, most preservice teachers in this section appeared to embrace discussions on diversity (discussed further in Chapter 4). Issues related to diversity were also addressed using the following activities, assignments, and discussions:

- The Draw-A-Scientist Test (DAST): Students drew what they thought a scientist looked like and the reasons behind those depictions
- Multicultural Awareness Quiz: A quiz which often illustrates how an individual’s perceptions of reality and what is actually fact are often in conflict (see Appendix H)
- Autobiographical Narrative Assignment: Students wrote about how aspects of their identity (e.g. race, ethnicity, culture, class) may affect their teaching
- Howard Gardner’s Multiple Intelligences and their use in the science classroom
- Discussion Board Questions: Students responded to the following questions:
  - One of the goals for scientific literacy is that all students, regardless of gender, cultural or ethnic background, physical or learning disabilities, aspiration, or interest and motivation in science should have the
opportunity to attain higher levels of scientific literacy than they currently do (NRC, 1996, p. 6). What is your view of this goal?

- What does multicultural science education mean to you?
- Racially/ethnically diverse minorities and women remain underrepresented in science related fields. Why do you think this is?

Class discussions were then followed by a 15 minute break. After the break, Instructor Roberts implemented inquiry-based science activities with the preservice teachers for the first 6 weeks. These activities focused on the importance of knowing, and understanding, the science content being presented and how to engage students in the lesson by using Gardner’s Theory of Multiple Intelligences. The remaining weeks consisted of preservice teachers preparing and implementing inquiry-based mini-lessons with their peers. Debriefing sessions concluded the day’s agenda. During this debriefing time, preservice teachers and the instructor provided the group (usually 3 preservice teachers) that was presenting the day’s mini-lesson with positive feedback and constructive criticism.

Section three. Preservice teachers enrolled in section three met at the university’s main campus in a classroom located on the third floor of the education building. This section was taught by Instructor Edwards and did not have an embedded service-learning component. The course structure was amorphous at times. Instructor Edwards stated that although courses which integrate a constructivist framework are often perceived as amorphous, it is an environment that allows for students’ voices to be heard (Instructor Edwards, personal communication, June 8, 2006). Therefore, the following description summarizes the general routine that was observed by the researcher.
Class usually began with housekeeping procedures. This time was used to make students aware of any modifications to the syllabus, such as the postponement of assignments, and to discuss the assigned reading or activity for the following week. Readings included chapters from the required textbook, Janice Koch’s (2001) Science Stories to articles such as Watson and Konicek’s (1990) Teaching for Conceptual Change. Article discussions were facilitated through the use of collaborative groups, which allowed students to work together and share their interpretations of the readings. These interpretations were then summarized by the group’s spokesperson and presented to the rest of the class. As opposed to Instructor Roberts’ class, few, if any, of the readings addressed issues related to diversity. Instead, this issue was slightly touched upon at the beginning of the semester with the Draw-A-Scientist Test (DAST) and Becoming a Scientist Biography Activity (discussed further in Chapter 4).

After housekeeping procedures, students were asked to share some of the experiences they had with science during the week. There was not much discourse during this portion of the class. The majority of students remained silent. This silence may be attributed to the fact that students did not perceive any of the experiences that had during the week as science related.

Discussions were then followed by a 15 minute break. At the conclusion of the break, students were engaged in inquiry-based, or collaborative, activities which consumed the remaining portion of class time. Plant growth and water’s unique properties were a few of the science concepts investigated by students. Journaling was used to record student observations and raise questions about the concept under study. Students were asked to share their observations with peers and formulate ideas for future
investigations. During the last half of the semester, according to Instructor Edwards, a good deal of this time after break was spent in curriculum planning.

The Instructors

Instructor Roberts. Instructor Roberts, is a white, monolingual, middle-class female. She was a high school physics teacher for two years and has been teaching elementary science methods courses for two semesters. The purpose of her science methods course, as outlined in the syllabus, was to assist preservice teachers in developing and practicing a reflective pedagogy in order to enhance their abilities to teach science effectively. Instructor Roberts believes that an effective science teacher is one who is confident in both the content knowledge and pedagogical content knowledge. Instructor Roberts states, “without this in depth [content] knowledge, [preservice teachers] can’t really use their pedagogical knowledge to meet the students wherever they’re at” (Instructor Roberts, personal interview, February 6, 2006). This was highlighted in her classes with her well-known phrase of “content, content, content.” In other words, you cannot teach, or adapt, what you do not know. She also attempted to create a safe environment for preservice teachers to purposefully and critically examine their preexisting beliefs about science, teaching science, and diversity. This was accomplished by giving preservice teachers a voice in the development of the classroom framework (i.e. course rules) and the weekly use of reflections that were read by the instructor and used to modify the curriculum to meet students’ needs.

Science methods courses were student centered. Even though there were instances where her views were imposed and students’ voices silenced, Instructor Roberts encouraged active listening and looking at ideas from diverse perspectives. Students
learned how to evaluate information relevant to themselves, their needs and the needs of their students.

Instructor Roberts’ philosophy of science teaching is underpinned by the following beliefs: 1) Role modeling effective teaching practices is essential; 2) Providing effective and diverse experiences for preservice teachers allow him or her to reflect on their past experiences with science and provides a knowledge base to draw upon; 3) Incorporating transformative experiences provide opportunities for preservice teachers to view old ideas from a new perspective; 4) Creating a safe forum for free discussion and exploration is a valuable tool in learning and teaching; and 5) It is important to facilitate an understanding of the diverse views preservice teachers will encounter inside and outside of the classroom in order to develop cultural consciousness (Instructor Roberts, personal interview, February 6, 2006). Instructor Roberts summarized her philosophy of science teaching with the following statement: “To become a good learner, we have to have confidence in our ability to learn, become aware of ourselves in a social human condition. Self awareness of human condition will allow us to become open to learning and encourage self-efficacy, which would open us up to learning because without that we are limited and can’t let anything else in” (Instructor Roberts, personal interview, February 6, 2006)

Instructor Edwards. Instructor Edwards is also a white, monolingual, middle-class female. She taught 10th-grade Biology for 4 years. In addition, she has been teaching science methods courses for over 10 years. She has designed her science methods course to address the following questions:
• What is science? Who does science? What is the role of science in society?

• What do kids think about science? Why do their ideas matter? How can teachers find out what these ideas are? How can knowledge of kids’ thinking shape instruction?

• What does thoughtful planning and teaching in science look like?

• How can we create powerful learning opportunities for all children to learn and understand scientific ideas?

Instructor Edwards believes that an effective science teacher pays attention to how children think. This is important because the ideas that children bring to the classroom greatly influence what you can teach them. She also believes that paying attention to student thinking shows them respect and allows them to think of themselves as good thinkers, learners, and people who can be successful in science. These beliefs are underscored by the aforementioned questions which her class has been designed to address.

Instructor Edwards realizes that there are barriers in place which prevent all children from envisioning the possibility of achieving scientific literacy and contends that “we should work to bring them down” (Instructor Edwards, personal interview, February 8, 2006). However, beyond explicitly emphasizing the belief that all children can do science which was highlighted with the DAST and Scientist’s Biography activities, the researcher did not observe discussions centered on diversity issues. Since the researcher did not attend all course sessions, Instructor Edwards stated that issues of diversity were also addressed with the following assignments/activities:
• Unit plan: Students were required to consider diversity issues in their planning.
• Spontaneous discussions on diversity.
• Journal Writing: What it takes to be a good science teacher? More specifically, the following statement was posed:
  - I asked you last week how you thought these views (of who does science) might affect children. Now I’d like you to focus on: Who does science? What is science? Explain your views on these briefly, then explain how you think this view of “who does science” and “what science is” might affect your thinking. (Instructor Edwards, personal communication, June 8, 2006)

Instructor Edwards acknowledged that although she felt it was important to be explicit about the idea that some people have been kept out of the science field because of racism, classism, sexism, etc., she wasn’t doing enough to prepare teachers for the diversity they will experience in the science classroom (Instructor Edwards, personal interview, February 8, 2006).

Since the majority of her students are white, working/middle-class women and have been taught that they are not good in science, one of her goals was to help them to see that they can do science and therefore teach it well. Accordingly, her philosophy of science teaching is undergirded by the belief that preservice teachers should understand that although science has a culture, ways of talking and interacting with the physical world, that science is not a “mysterious thing that only special, mostly white male middle and upper class people can do” (Instructor Edwards, personal interview, February 8, 2006).
Instructor Edwards provided several opportunities for preservice teachers to engage in inquiry-based science activities. These activities were important for two reasons. First, it allowed preservice teachers an opportunity to engage in hands-on science, which is something many may have not experienced during their K-12 years. Second, they provided a conduit for Instructor Edwards to interweave learning science content (i.e. properties of water and plant growth), an area many preservice teachers felt they were weak in understanding. Another overarching goal of the course was to help preservice teachers create powerful learning opportunities for all children to learn science. The instructor hoped that students would develop perspectives and methods that allowed them to 1) feel confident in teaching science; 2) become excited about teaching science; and 3) become reflective practitioners. The instructor anticipated that these outcomes could be achieved by allowing preservice teachers opportunities to participate in hands-on science activities and by creating assignments that allow students to examine their own assumptions and beliefs about scientific knowledge, scientific inquiry, and the teaching and learning of science. Table 3 provides a general overview of both instructors.
Table 3.

General Overview of Instructors

<table>
<thead>
<tr>
<th>Personal Characteristics</th>
<th>Instructor Roberts</th>
<th>Instructor Edwards</th>
</tr>
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<td>Race/Ethnicity</td>
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<td>Caucasian</td>
</tr>
<tr>
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<table>
<thead>
<tr>
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University Area Community

This community surrounds the university’s main campus. The neighborhood is plagued with a high crime rate, decay, a lack of basic resources, and depressing poverty. Nicknamed “Suitcase City” for its large transient population, this community consists of 40,000 residents and more than 15,000 children (University Area Community Development Corporation, 2005). It resembles what is usually found in a depressed urban inner-city area (i.e. dilapidated housing, high crime rates, schools with limited resources, little to no community resources, and few recreational programs for the area’s children).

The University Area Community has experienced: 1) aggravated assaults that are three and a half times the county’s average; 2) rapes that average one and a half times the
county’s average; 3) robberies at nearly six times the county’s average; and 4) drug related crimes at seven times the county’s average (University Area Community Development Corporation, 2005). The area’s crime rate is four and a half time the county’s average and among the highest in the state. Documents reveal that juveniles commit the majority of the area’s crimes. According County’s Sheriff’s Office, juveniles committed 34,758 Part I crimes in 1998. Of these crimes, 3,311 were committed in the University Area Community (University Area Community Development Corporation, 2005).

Community Center/Elementary Students. The community center is located in an urban neighborhood in the university area community. It is considered an “inner city depressed area.” The children in this area rank first with the county’s health department in immunization non-compliance (University Area Community Development Corporation, 2005). There are very few real diversionary or recreational opportunities available to these children. With only two schools, one county park and no library, the area’s children have very limited resources.

There are more than 14,000 children in this neighborhood who live within a 10-mile radius of the center, yet most school-age children attend schools outside of the community. Almost 90% of all school-aged children in this area receive free or subsidized lunches. The children’s families are very mobile, with attrition rates ranging 55% to 75% from year to year. In addition, the children in this community have poor school attendance, lack parental involvement, and have low academic achievement scores on national and state assessment instruments. Scores on both instruments have revealed
that these “at-risk” children rank in the bottom one-third of all students tested nationally (University Area Community Development Corporation, 2005).

The purpose of community-based service-learning is to connect academic content to community service. Therefore, it was necessary to identify and address the needs of the local community in regard to educating their youth. The community center director requested that, whenever possible, preservice teachers 1) scaffold off of the elementary students’ previous knowledge by utilizing a spiraling curriculum; 2) integrate inquiry-based science lessons; and 3) connect the science lessons to students’ lived experiences. One of the ways Instructor Roberts attended to the aforementioned requests was to make sure that preservice teachers provided what they considered to be “real-life” connections between the inquiry-based science activity and students’ lives in their lesson plans. Lesson plans were given to Instructor Roberts, a week before they were to be implemented, for approval. This approval process was also used to make sure that 1) the science content was accurate and 2) higher order objectives and questions were being utilized.

Additionally, most preservice teachers had their students fill out a student interest inventory at the beginning of the semester. The researcher observed some preservice teachers making real-life connections by integrating students’ interests into their science lessons. For example, one preservice teacher group found out that the majority of their students enjoyed rap music. Therefore, they composed a rap song related to moon phases. In addition to performing this rap song, students were encouraged to make up their own song. Another group found out that their students were interested in technology. In order to engage students in one of their science lessons, this group used
an Internet Web Quest to facilitate what they considered to be a real-life connection. Preservice teachers were also observed making real-life connections between students’ home experiences (e.g. cooking, showering, sports, and geographic location) and the science lesson.

Approximately 55 elementary students participated in this community-based science methods course. The word “approximately” is used because the number of elementary students varied due to the high attrition rates of the surrounding community. The ethnic/racial composition of the students, based upon the information given by the community center, was as follows: 75% African American/Black, 15% Caucasian/White, and 10% Latino/Hispanic. The socioeconomic levels of the students range from 70% low to moderate to 30% above low to moderate.

Instrumentation

This section describes the instruments that were used during the study. A mixed-methods approach was utilized. Questions one, three, and four were investigated with the use of qualitative instruments. Question two was investigated with the use of quantitative instruments. The summary that follows is separated into two sections: quantitative methodology and qualitative methodology. Refer to page 121 to view research question one.

Quantitative Methods

*Quantitative Instruments*

Research question two, science teaching efficacy regarding teaching diverse students, was measured using the Self-Efficacy Beliefs about Equitable Science Teaching (SEBEST) instrument (Ritter et al, 2001). The independent variables were the course
sections: Section one, Section two, and Section three. The dependent variables were the mean difference between the pretest and posttest scores for Personal Science Teaching Efficacy (PSTE) and Science Teaching Outcome Expectancy (STOE). The SEBEST consisted of 34 items that assessed the self-efficacy beliefs of preservice teachers with regards to science teaching and learning for diverse students. Ritter et al. (2001) define diverse learners as those groups who are underrepresented in science related fields (racial/ethnic minorities and girls) and those from low socioeconomic backgrounds.

The SEBEST is a modification of the STEBI-B (Enochs & Riggs, 1990). The 5 choice Likert-scale response categories range from “strongly agree” to “strongly disagree.” The SEBEST consists of two subscales. The first, personal science teaching efficacy, is defined as science teachers’ “judgments about how well one can organize and execute courses of action required to deal with prospective situations that contain ambiguous, unpredictable, and often stressful elements” (Bandura, 1977, p. 201). The second subscale measures science teaching outcome expectancy. This subscale assesses preservice elementary teachers’ beliefs that given effective teaching, all students can learn (Bandura, 1977).

Reliability and Validity. Ritter et al. (2001) conducted many studies to examine the reliability and construct validity of the SEBEST. In the first study, the SEBEST was administered to 217 preservice elementary teachers. The Coefficient Alpha reliability for the entire instrument was found to be 0.87. Based on this sample, the reliability for the 17-item PSTE subscale was 0.83, and 0.78 for the 17-item STOE subscale. Next, two other samples of prospective elementary teachers were used to verify the aforementioned reliabilities. One sample contained 23 preservice elementary teachers registered for a
methods course given in Spring ’99 and the other sample consisted of 102 preservice elementary teachers registered for a Fall ’99 methods courses. The reliabilities for the Spring ’99 course were 0.90 for the entire instrument, 0.81 for the PSTE subscale and 0.88 for the STOE subscale. The reliabilities for the Fall ’99 courses for the entire instrument and its two subscales were 0.88, 0.83 and 0.85 respectively. The construct validity was measured to be 0.81 for the outcome expectancy subscale and 0.98 for the personal efficacy subscale.

In order to assess the content validity of the instrument, draft items of the SEBEST were reviewed for clarity and understanding by ten science education graduate students. A panel of eight experts also evaluated content items. The panel of experts consisted of faculty members from science education and multicultural education, and researchers in the field of self-efficacy. They agreed that the content items were valid. These statistics help to suggest that the SEBEST is a reliable and valid instrument.

Data Collection

The researcher obtained approval from the university’s Institutional Review Board (IRB) before data collection began. During the first course meeting at the beginning of the semester, participants were asked to give informed consent for study participation, although the research study posed no anticipated threats. Participants were assured both orally and in writing that their participation in the study was voluntary. In addition, they were informed that their course grades would not be affected if they decided not to participate in the study. The confidentiality of their responses was also made explicit, both orally and in writing.
Changes in self-efficacy beliefs were measured using the SEBEST instrument (see Appendix A). The instrument was given at the beginning and end of the Spring ’06 semester to preservice elementary teachers registered in three sections of SCE 4310. It was hypothesized that $\mu_1 = \mu_2 = \mu_3$. That is, there would not be a significant difference among the mean scores (posttest mean scores – pretest mean scores) of preservice teachers in Section one, Section two, and Section three.

**Test Reliability.** Reliability is defined as the measure of a test’s internal consistency. The Cronbach’s alpha coefficient, which was named after Lee Cronbach (1951), is used to estimate the internal consistency of a test. Although it may be used on test items where the answers are either right or wrong, it may also be used to determine the reliability of test items given a range of scores, such as Likert-scaled items. Because item choices on the SEBEST range from 1 to 5, the Cronbach alpha was used to estimate the test’s reliability.

**Data Analysis**

Statistical Package for the Social Sciences (SPSS) was used to run descriptive and inferential statistics on the three populations under study. More specifically, the researcher utilized two 3 x 2 Factorial Repeated-Measures ANOVAs to determine whether there was a statistically significant difference in the mean scores of the two subscales of the SEBEST, among the three populations of preservice teachers enrolled in three different science methods sections. Since equal sample sizes are not a requirement of ANOVA designs and a pretest-posttest format was utilized in order to obtain difference scores, a Factorial Repeated-Measures ANOVA design was most appropriate for the purposes of this study.
Homogeneity of variance may be affected by unequal sample sizes. Although the ANOVA is robust to moderate violations of homogeneity of variance, because participants self-register for their courses, violations of homogeneity were a concern of the researcher. Therefore, Levene’s test (Stevens, 1999) was employed to make certain that the assumption of equal variances was not violated. Next, a two-tailed was performed at the 5% significance level for the two subscales of science teacher efficacy because it is unclear whether self-efficacy scores can be predicted to increase or decrease at different stages of a preservice teacher’s development (Hoy & Woofolk, 1990). The results obtained from the data analysis were used to identify significant mean scores. Based on these scores, a description of the population was provided.

Qualitative Methods

Researcher bias

My reasons for choosing this research study are three-fold. First, as an African American, monolingual, working-class female, my interest was aroused after noticing that the academic gap between students of color and white students and urban/rural students and suburban students in science continued to persist.

Second, after many conversations with white preservice teachers, most indicated that they felt confident in teaching science, or any subject, to diverse student groups even though they had very limited, if any, intercultural experiences. As a researcher, and a science teacher who was immersed in a different racial/ethnic and cultural school environment for seven years, I began to question whether or not these preservice teachers possessed a false sense of security because they didn’t understand the complexities that
may be associated with teaching students from different sociocultural backgrounds than themselves.

Third, when the director of the community center gave a former class of preservice elementary teachers a tour of the community center, some preservice elementary teachers felt like such a “nice” community center shouldn’t be in a “dirty area like this.” In another class, one preservice teacher commented that she “wasn’t trained to work with special needs children.” However, none of the community center children had ever been referred to, or qualified for, special education.

With the call for high academic success for all students (NCLB, 2001; NRC, 1996), especially that of K-12 students, I began to question how this goal could be reached when many preservice teachers subscribe to beliefs which undermine the call for reformation. I felt that it was very important for preservice teachers to be immersed in an environment, for an extended period of time, to have their preexisting belief systems challenged, thereby allowing them an opportunity to accommodate new information. This accommodation of new knowledge may lead to the conceptualization of an effective pedagogy inclusive of all students; making “science for all” a realistic goal. Therefore, I realize that I bring much subjectivity to this research study.

Qualitative Instruments

Contradictory to the objective truths proposed by a quantitative research paradigm, a qualitative approach takes into consideration the following points:

1. People are active participants in meaning-making activities
2. Situations are fluid; therefore behavior changes over time and is context dependent
3. Since individuals are unique, results may not be generalizable
4. People base their behaviors on their interpretation of events, situations, or contexts
5. There are multiple interpretations and perspectives for a situation or event
6. Reality is dynamic and complex
7. The perspectives of a participant are just as important as those of a researcher (Denzin & Lincoln, 2000; Lincoln & Guba, 1985).

Since reality is an interpretation of the mind and knowledge is a dynamic product of the mind which manifests itself in practice, the researcher attempted to understand how meaning was constructed from multiple perspectives (i.e. multiple data sources, data collection, analysts). Therefore, this study subscribed to the qualitative paradigm of constructivism.

Constructivism is an interpretive stance which attends to the process of meaning-making. Meaning is constructed from “both physical and temporal data, acquired through the senses, and the interaction of these physical and temporal data with values, beliefs…attitudes, and stereotypes” (Lincoln, 2004, p. 60). These constructions are critical because they determine how individuals will act toward each other. In addition, they also determine how an individual will interpret events which thereby affect their performance (Lincoln, 2004). For the purposes of this study, it was very important to understand what experiences, if any, fostered the construction of preservice elementary beliefs about multicultural science teaching, characteristics of effective science teachers, and positive self-efficacy beliefs regarding equitable science teaching and learning. High science teaching efficacy beliefs about equitable science teaching and learning are
important because low science teaching efficacy beliefs may undermine the goal of producing a scientifically literate populace (NRC, 1996).

Semi-Structured Interviews. Quantitative results can sometimes be dismissed on methodological or political grounds, simply because a select few may disagree with the study’s findings (Patton, 2002). However, it may be more difficult to dismiss the actual words of a participant. Patton (2002) gives the following example. A school board dismissed survey results that measured teacher satisfaction. They said that the finding of teacher dissatisfaction was simply indicative of lazy teachers who did not want to be held accountable for their work. However, when the board members were presented with actual teacher quotes that reflected both their commitment to the job and deep concerns about the problems of this particular educational system, the school board became more willing to hear and address teachers’ concerns. Therefore, this study utilized qualitative interviews; more specifically, semi-structured interviews.

Semi-structured interviews, along with open-ended questions that were incorporated in the post-questionnaire, were used to obtain information about 1) research question one, characteristics of effective science teachers; 2) research question three, sources of efficacy; and 3) research question four, beliefs about multicultural science teaching. Sample interview questions are listed in Table 4.
Table 4.

Sample Interview Questions addressing Study’s Inquiry

<table>
<thead>
<tr>
<th>Research Questions</th>
<th>Sample Interview Questions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beliefs about Multicultural Science Teaching</td>
<td>How, if at all, will your students’ racial/ethnic, cultural, language and socioeconomic backgrounds affect your science teaching?</td>
</tr>
<tr>
<td>Effective Science Teachers</td>
<td>What are the characteristics of an effective science teacher?</td>
</tr>
<tr>
<td>Sources of Efficacy</td>
<td>What specific course experiences, if any, had a positive effect on your ability to teach diverse populations.</td>
</tr>
</tbody>
</table>

Open-ended questions were utilized in a semi-structured format. Open-ended questions provided the researcher with quotations, which were a rich source of data. Patton (2002) notes that quotations reveal the participant’s emotional levels, how they organize the world, thought patterns, along with their experiences and perceptions. Patton (2002) suggests that some of the benefits involved with the use of these types of interviews are that they can be used with numerous data analysis techniques, provide an environment where participants can express extreme or deviant views without fear of being judged by others, allow for a mix of interview and conversation, and they allow the interviewer to incorporate the interviewee’s responses into future questions. Semi-structured interviews were deemed appropriate for this study because they will allow the researcher to gain insight into the attitudes and perceptions of participants and provide insight into SEBEST results. All interviews were conducted in person. The average interview took approximately 20 minutes with a range from 15 to 30 minutes. Interviews were tape-recorded and transcribed for analysis.

*Interviewer.* The researcher can be considered an instrument in qualitative interviewing (Patton, 2002). An interviewer can be affected by factors such as
personality, knowledge, level of skill, and experience. While the aforementioned factors can be considered threats to validity, they can also be considered strengths. An experienced interviewer can use flexibility and insight to gain in-depth knowledge of the participant’s experience. In addition, an experienced interviewer should be sensitive to non-verbal messages, environmental effects, and the nuances of the interviewer/interviewee relationship.

Due the sensitivity of the subject matter under study, the researcher realized that her ethnicity may pose a threat to validity. Therefore, three skilled interviewers conducted participant interviews: the researcher and two interviewers of Caucasian descent. The two additional interviewers had already received training in the art of interviewing and strengthened the study’s credibility. Although the interviewers had already been trained in appropriate interview techniques, the researcher will held one session to discuss Kvale’s (1996) qualities of a skilled interviewer (see Table 5), along with the study’s purpose and topics under investigation.
### Table 5.

Qualities of a Skilled Interviewer

<table>
<thead>
<tr>
<th>Qualities</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Knowledgeable</td>
<td>Become thoroughly familiar with the research study’s purpose and topics under investigation</td>
</tr>
<tr>
<td>Structuring</td>
<td>Explain the purpose of the interview to the interviewee and ask if there are any questions</td>
</tr>
<tr>
<td>Clear</td>
<td>Try to make questions as clear as possible.</td>
</tr>
<tr>
<td>Gentle</td>
<td>Wait for interviewees to finish answering the question before moving on to the next one. Be patient and tolerant of pauses. Allow think time.</td>
</tr>
<tr>
<td>Sensitive</td>
<td>Show attentiveness to what is being said</td>
</tr>
<tr>
<td>Open &amp; Flexible</td>
<td>Recognize and respond to what the interviewee feels is important</td>
</tr>
<tr>
<td>Steering</td>
<td>Remember what you want to find out</td>
</tr>
<tr>
<td>Critical</td>
<td>Be prepared to politely challenge inconsistencies in the interviewee’s responses</td>
</tr>
<tr>
<td>Remember &amp; Integrate</td>
<td>Although semi-structured, there may be times where it is appropriate to relate what is said to what has previously been said</td>
</tr>
<tr>
<td>Interpreting</td>
<td>Try to clarify and extend meaning of the interviewers statements without changing their meaning</td>
</tr>
</tbody>
</table>

Pre-Post Questionnaires. Questionnaires are flexible in what they can measure.

In addition, they can be given to may participants in a short amount of time. The questionnaires used in this study combined both close-ended and open-ended questions. Data obtained from the questionnaires aided the researcher in developing a rich description of the study’s participants, sources of efficacy, and attitudes (see Appendix D). The pre-questionnaire obtained information about participants’ age, gender, ethnicity, undergraduate/graduate status, socioeconomic level, and current confidence level in teaching science to diverse populations. The post-questionnaire obtained information about the course experiences that affected participants’ science teaching
efficacy beliefs about teaching science to diverse populations and the overall effect of the method’s course.

Passive Observation. Constructivist observations range from that of the complete observer to the complete participant (Patton, 1990). The researcher assumed the role of the complete observer to record detailed field notes. This means that the researcher attempted to remain detached from the situation being observed in hopes that she would not distort participants’ behaviors.

Data Collection

Research question one investigated what characteristics preservice elementary teachers ascribed to effective science teachers. Research question three sought to determine what course experiences, if any, affected preservice elementary teachers’ science self-efficacy beliefs about teaching science to diverse learners. Research question three explored how preservice elementary teachers’ beliefs about multicultural science teaching changed over the semester. Semi-structured interviews, field observations, and questionnaires were used to explore answers to these questions. Purposeful sampling was employed to select participants for personal interviews. The appropriate purposeful sampling method was chosen based upon the class demographics. Due to the limited presence of diversity in the science methods courses, the researcher used stratified purposeful sampling procedures, selecting participants based on race/ethnicity and gender.

Pilot Study. Thirty-two preservice elementary teachers enrolled in two science methods courses participated in the pilot study. The demographics of the study’s participants were as follows: 26 White/Caucasian females, 2 Black/African American
females, 1 Hispanic/Latina female, 2 Asian/Pacific-Islander females, and 1 White/Caucasian male. This pilot study served two functions. The first was to determine the reliability of the two subscales of the SEBEST instrument using Cronbach’s alpha. The calculated reliability was 0.93 for the entire instrument, 0.84 for the PSTE and 0.91 for the STOE. These figures suggest that the SEBEST is a reliable instrument.

The second function of the pilot study was to determine whether or not the proposed interview questions would generate in-depth knowledge of preservice elementary teachers’ beliefs about equitable science teaching. Eight preservice elementary teachers participated in semi-structured interviews regarding their beliefs and attitudes about equitable science teaching and learning (4 White/Caucasian female, 2 Black/African American females, 1 Hispanic/Latina female, and 1 Asian/Pacific-Islander female). The interviewer, who was also the researcher, asked participants questions such as, “Does race, ethnicity, gender, class, or culture play a role in the science classroom? Does race, ethnicity, gender, class, or culture play a role in your expectations of students’ academic success in science? Do you feel confident in your ability to teach science to children whose racial, ethnic, class, and/or cultural backgrounds may be different than your own?” After each question, the participant was asked to justify his/her position. Most preservice teachers espoused superficial views about equitable science teaching. For example, most participants felt that race, ethnicity, gender, class, or culture would not play a role in their science classroom, because they would treat all students equal. However, one preservice teacher, based upon her experiences in previous science courses, felt that the aforementioned factors (race, ethnicity, etc.) did play a role in the science classroom. She indicated that it was requisite to acknowledge the contributions
of different ethnicities and cultures to the scientific enterprise. As an Asian-American, she felt marginalized because Asian scientists were not visible in the science curriculum. She did not want students to feel marginalized because of her science curriculum. The emergent theme from participants’ interviews was that they felt that it was more important to focus on their students’ commonalities rather than their differences. If this “unifying” process was done correctly, participants felt like nothing else would matter since we are all Americans.

Due to the perceived superficiality of participants’ responses, the researcher formulated a new interview protocol. After the new interview protocol was created, peer debriefing was used because it allowed the researcher to test insights and interpretations. Three university professors, two doctoral students, and 5 preservice elementary teachers checked the questions for clarity and content. A few minor modifications were suggested, and made, for the final interview protocol (refer to Appendix B). The researcher believed that the new questions would garner a deeper understanding of preservice teachers’ beliefs regarding equitable science teaching and learning.

*Research Study.* Semi-structured interviews were conducted at the beginning and end of the Spring ’06 semester. Each interview session lasted approximately 20 minutes and was audiotaped. Patton (1987) suggests that there are many advantages to tape recording interviews. These advantages include:

- Tape recorders do not tune in and out of the conversation;
- Tape recorders do not interpret what is being said;
- Tape recorders do not speed up or slow down the conversation;
- Tape recorders do not miss what is said; and
• Tape recorders allow the interviewer to concentrate on the interview

Pre- and post-questionnaires were given at the beginning and end of the semester to all participants in the research study. Interviews and questionnaires were used to identify the characteristics of effective science teachers, determine what course experiences affected science teaching efficacy beliefs about equitable science teaching, and examine preservice teachers’ beliefs and attitudes regarding multicultural science teaching.

Additionally, the researcher attended 7 class sessions for each of the three science methods sections. The researcher observed each session for approximately 2 ½ hours. The researcher was positioned in the back of the classroom and remained as unobtrusive as possible. Field observations provided the researcher with first-hand information. Observations were conducted to 1) document the course structure; 2) record the instructor’s pedagogical style; 3) document the classroom culture (e.g. norms, student demographics, behavioral patterns); and 4) obtain information that my be used to form new interview questions. Field notes were written up as soon as possible after leaving the research site each session. These field notes included the researchers’ observations and subjective interpretations.

Data Analysis

The current investigation attempted to provide a detailed description and interpretation of the influence of community-based service-learning on preservice teachers’ self-efficacy beliefs and pedagogical beliefs about equitable science teaching and learning. This description was provided by analyzing participants’ interviews, course observations, and questionnaires. Qualitative data analysis was performed using the perspective of grounded theory. This theory allowed participants’ responses to define the
categories that were used in the analysis. This framework provided some standardization and rigor (Patton, 2002).

Using constant comparative data analysis (Glaser & Strauss, 1967), data were analyzed for themes or patterns in relation to participants’ beliefs and attitudes about multicultural science teaching, sources of science teacher efficacy, and characteristics of effective science teachers. Data were then coded and categorized (Patton, 2002). This method is also recommended by Lincoln and Guba (1985) because “it is less extreme, partly because it makes explicit the continuous and simultaneous nature of data collection and processing, and partly because its procedures have been well explicated by Glaser and Strauss (1967)” (p. 336). Since this is a creative and interpretive process, the researcher was careful in making judgments about the significance and meaning that was generated from the data.

Inductive analysis was used to allow patterns, categories, and themes to “emerge out of the data rather than being imposed on them prior to data collection and analysis” (Patton, 1990, p. 390). It was expected that the themes and patterns would be modified as data was collected and analyzed because data analysis is an iterative process. Therefore, the researcher worked back and forth between “logical construction and actual data in search of meaningful patterns” (Patton, 1990, p. 411). Dominant themes were identified through selective coding. The researcher then linked and reorganized the themes when appropriate. In order to reduce researcher bias, a third party was asked to examine the data analysis process as information was collected and coded.

**Inter-rater Agreement.** Inter-rater agreement refers to the extent to which independent coders evaluate a characteristic(s) of a text and reach similar conclusions.
Two transcripts were randomly selected and reviewed independently by the researcher and another evaluator. Codes and categories were developed independently based on thematic analysis of the data. The researcher and evaluator discussed the codes and categories that each had developed independently. Coding decisions were discussed to discover and increase inter-rater agreement and trustworthiness (Lincoln & Guba, 1985). When there was disagreement with respect to a particular label assigned to the data, the process was repeated until consensus was reached. During this peer debriefing and collaborative coding process, refinement occurred and rules for inclusion were established.

After consensus, thirty percent of the transcripts were reviewed independently to identify categories, patterns, and themes. The researcher and evaluator met again and established inter-rater agreement of 90% (Sadler & Zeidler, 2004). The researcher continued to code the remaining transcripts based upon the established codes and rules for inclusion.

**Trustworthiness.** The researcher paid close attention to the criterion of trustworthiness when she carried out this constructivist inquiry. According to Lincoln and Guba (1985), trustworthiness of qualitative research is established by attending to issues of credibility, transferability, dependability, and confirmability. Credibility is tantamount to internal validity from quantitative research. If a study is judged to be credible, that means its findings are valid. In order to attend to issues of credibility within this study, the researcher used prolonged engagement, persistent observation, member checking, and triangulation.
Prolonged engagement refers to the “investment of sufficient time to achieve certain purposes, learning the ‘culture’, testing for information introduced by distortions either of the self or the respondents, and building trust” (Lincoln & Guba, 1985, p. 301). The current study took place between January 2006 and May 2006. The researcher attended twenty-one sessions; seven for each of the three science methods courses offered. Merriam (1988) asserts that “an observer cannot help but affect and be affected by the setting, and this interaction may lead to a distortion of the real situation” (p. 103). This may be referred to as observer effect. Prolonged engagement allowed the participants to become familiar with the researcher in an effort to minimize the effect of the researcher on the participants. It allowed the participants an adequate amount of time to get used to the researcher being in the classes (Lincoln & Guba, 1985). The researcher was aware of the implications of becoming over-involved with the participants. Therefore, the researcher positioned herself as a passive observer as much as possible. In addition, any biases and subjectivities were recorded in the field notes.

Lincoln and Guba (1985) state, “If the purpose of prolonged engagement is to render the inquirer open to the multiple influences…the purpose of persistent observation is to identify those characteristics and elements in the situation that are most relevant to the problem or issue being pursued…If prolonged engagement provides scope, persistent observation provides depth” (p. 304). Passive observations were used in this study. Observations were recorded in the form of field notes. The researcher revisited the notes to identify emergent themes. This recursive process aided in subsequent observations where the researcher confirmed or disconfirmed themes discovered in previous stages. While data collection was in progress, the researcher also revisited the notes to sort
relevancies from irrelevancies. In short, persistent observations allowed the researcher to obtain in-depth and accurate data.

Humans are instruments. They provide an easy way to obtain member checks and make incredible data credible. During the interviews, the researcher attempted to restate or summarize the information that was received from the interviewee to ensure that what was written or heard was correct. After data collection, preliminary findings were reported back to the participants. They were asked to critically examine the data for inaccuracies and clarification. Member checks added to the study’s accuracy and richness.

Triangulation allows the researcher to verify data. There are several forms of triangulation. The researcher triangulated the data obtained from the three courses and their participants. Methodological triangulation was employed by collecting several sources of data (i.e., interviews, questionnaires, the SEBEST, and field notes). Additionally, multiple interviewers and coders participated in the data collection and analysis.

Transferability. Transferability is similar to external validity from the quantitative paradigm. The purpose of a quantitative study is to be able to generalize its findings to a larger audience. However, in the case of qualitative research, no true generalizations are possible because all observations are defined by the study’s context. With that said, the knowledge gained from this study’s context may not have relevance in another context, even if the same procedures are followed. Therefore, the obligation for determining whether or not findings from this study may be transferable belongs to the reader. In order to aid in the study’s transferability, the investigator kept field notes to document
research decisions and record subjectivities and biases. In addition, the researcher attempted to provide thick descriptions. These descriptions will allow the reader to live vicariously through the researcher’s experiences and make judgments about transferability.

Dependability and Confirmability. Dependability is similar to reliability from quantitative research, whereas confirmability is similar to objectivity. Both may be established by providing an audit trail for the study. Therefore, a multicultural educator and researcher from a Midwestern university examined this study before, during, and at the end of the study’s completion. An audit trail of raw data, such as interviews, transcripts, and field notes were examined. In addition, data reduction, comparative analysis, and member checks were also examined. After examination, the auditor sent back a summary of suggested modifications and areas of clarity. The majority of suggestions were related to the collapsing of categories. Therefore, based on these suggestions and the study’s purpose, most of the auditor’s concerns were addressed.

Summary

I, as the researcher, acknowledge that my selection in choosing the proposed research study is not a neutral act. As an African American female who attended urban schools, I have a vested interest in understanding what practices will lead to the development of efficacious science teachers for all students. Cognizant of my biases, I continually examined, and reexamined, my own subjectivity to determine what effects, if any, it would have on the gathering and interpreting of data from this study.

The primary goal of this study was to determine the effects of community-based service learning on the science self-efficacy beliefs of preservice elementary teachers.
regarding issues of equity in science teaching and learning. Underpinning this primary goal was the need to 1) understand what experiences contributed to these self-efficacy beliefs; 2) describe preservice elementary teacher’s beliefs about multicultural science teaching; and 3) depict the characteristics preservice elementary teachers posit as belonging to effective teachers, not to pass judgment on those being studied. My intent was to build upon an existing theory through systematic descriptions and understandings. Because situations are complex, I attempted to delineate as many dimensions as possible, rather than narrow the field.

Furthermore, in an effort to guard against my own biases, I recorded detailed field notes that included my subjectivity. This may not be enough since I, like other qualitative researchers, may be affected by observation bias. In addition, I am sure that my presence, to some degree, may have changed participants’ behaviors. However, almost all research studies may be affected by this problem.

I will never be able to eliminate all of my own effects on the participants’ attitudes and behaviors. Nor will I be able to obtain perfect alignment between what I set out to study and what was actually studied. However, I attempted to understand the effects of course environment through an intimate knowledge of the setting. This was accomplished through the use of persistent observations. These observations were then used to generate additional insights into the nature of the relationships under study.

My expectation was that qualitative data would reveal preservice teachers’ own understanding of the interconnectedness of their beliefs about science teaching and the resulting behaviors. However, data analyses were subject to my interpretation of meaning. The construction of meaning from the data was done in a social context and
from a specific interpretive stance. The lens, which I used to construct personal meaning, was embedded with my own subjectivities. Bakhtin (1975, as cited in Plourde, 1999) reminds us that “…in everyday the everyday speech of any person living in society, no less than half (on the average) of all words uttered by him will be someone else’s words (consciously someone else’s), transmitted with varying degrees of precision and impartiality.” In summary, the results obtained from this study, both quantitatively and qualitatively, must be evaluated with the knowledge that all data has been subject to my exploration and interpretation of meaning in the domain specific area of preservice science teacher education.
CHAPTER FOUR: RESULTS

Introduction

The purpose of this study was to examine the effects of community-based service-learning on the self-efficacy beliefs of preservice elementary teachers on issues regarding equitable science teaching and learning. Qualitative and quantitative statistics together with the interpretation of results are organized by the question they address. Because most data was collected through semi-structured interviews, several quotations, taken directly from interview transcripts, are presented throughout the chapter (see Appendices E, F, and G for additional interview excerpts).

Research Question 1

RQ1. In what ways, if any, are the perceptions of preservice elementary teachers enrolled in a community-based science methods course with an embedded service-learning component different from those enrolled in two university-based science methods courses without a service-learning component with respect to their ideas concerning the characteristics of effective science teachers?

A teacher’s sense of self-efficacy mediates his or her behavior. Since most preservice teachers aspire to teach all students effectively (aspired beliefs), teachers’ ideological and pedagogical beliefs are equally important in determining behavior. Using their past experiences as filtering devices for teacher effectiveness, preservice teachers
enter their science methods courses with preconceived notions about the qualities they believe effective science teachers should possess. Therefore, preservice teachers’ aspired beliefs of effectiveness may influence his or her confidence in their ability to be effective science teachers of all students. In order to assess the characteristics preservice teachers ascribed to effective science teachers, pre and post-responses from the twelve interview participants, described in Chapter 3 (Table 2 has been copied below), to the following interview question were analyzed: What are the characteristics of an effective science teacher?

Interview Participant Characteristics

<table>
<thead>
<tr>
<th>Interview Participants</th>
<th>Ethnicity</th>
<th>Gender</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Section 1</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Erika</td>
<td>African American</td>
<td>F</td>
<td></td>
</tr>
<tr>
<td>Jason</td>
<td>Caucasian</td>
<td>M</td>
<td></td>
</tr>
<tr>
<td>Maria</td>
<td>Latina</td>
<td>F</td>
<td></td>
</tr>
<tr>
<td>Sarah</td>
<td>Caucasian</td>
<td>F</td>
<td></td>
</tr>
<tr>
<td><strong>Section 2</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Angel</td>
<td>African American</td>
<td>F</td>
<td></td>
</tr>
<tr>
<td>Natalia</td>
<td>Latina</td>
<td>F</td>
<td></td>
</tr>
<tr>
<td>Laura</td>
<td>Other</td>
<td>F</td>
<td></td>
</tr>
<tr>
<td>Kim</td>
<td>Caucasian</td>
<td>F</td>
<td></td>
</tr>
<tr>
<td><strong>Section 3</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Eric</td>
<td>African American</td>
<td>M</td>
<td></td>
</tr>
<tr>
<td>Michael</td>
<td>Caucasian</td>
<td>M</td>
<td></td>
</tr>
<tr>
<td>Kathy</td>
<td>Caucasian</td>
<td>F</td>
<td></td>
</tr>
<tr>
<td>Robin</td>
<td>Caucasian</td>
<td>F</td>
<td></td>
</tr>
</tbody>
</table>
Using constant comparative analysis (Glasser & Strauss, 1967), the following themes relating to preservice elementary teachers’ perceptions of characteristics of effective science teachers emerged from the data: teacher pedagogy and creating a learning community. Each of these themes, with their subsequent characteristics, in relation to the three course sections are shown in Table 6. The following discussion is presented around these two themes with supportive quotations extracted from interview transcripts. The quoted selections were chosen as evidence and are not exhaustive of all responses. Pseudonyms are used to preserve each participant’s anonymity.

Table 6.

Effective Science Teacher Characteristics

<table>
<thead>
<tr>
<th>Course Section</th>
<th>Teacher Pedagogy</th>
<th>Creating a Learning Community</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pre</td>
<td>Post</td>
</tr>
<tr>
<td>1 Roberts-CB</td>
<td>- Are engaging</td>
<td>- Are flexible</td>
</tr>
<tr>
<td></td>
<td>- Use diverse strategies</td>
<td>- Use diverse strategies</td>
</tr>
<tr>
<td></td>
<td>- Possess content Knowledge</td>
<td>- Possess content Knowledge</td>
</tr>
<tr>
<td>2 Roberts-UB</td>
<td>- Are engaging</td>
<td>- Are engaging</td>
</tr>
<tr>
<td></td>
<td>- Possess content knowledge</td>
<td>- Use hands-on activities</td>
</tr>
<tr>
<td></td>
<td>- Are prepared</td>
<td>- Are enthusiastic</td>
</tr>
<tr>
<td>3 Edwards-UB</td>
<td>- Are engaging</td>
<td>- Are engaging</td>
</tr>
</tbody>
</table>

Note: CB = Community-Based, UB = University-Based
* = No patterns emerged

Teacher Pedagogy
Teacher pedagogy was a theme that emerged across course sections and refers to the instructional methods teachers use to impart content knowledge. Examples of teacher pedagogy included engaging the students, being flexible, using students’ diverse learning styles and knowledge, and knowing the content material being discussed. In Section one, pre-interview results suggest that participants felt that it was equally important to engage students, be familiar with the science topic being taught, and to include some form of diversity in their instructional delivery. For example, Sarah commented that teachers should “make their students at least interested or curious about what they’re talking about.” Maria stated that an effective science teacher is “one that is open-minded to children’s necessities, like abilities culturally and linguistically.” In addition, Maria felt that the teacher should also “know the subject area.” Erika encountered teachers who were dependent on the textbook during her schooling experiences. Therefore, she responded that an effective science teacher “uses more than the book as a resource.” Similar results were noted for their post-responses. However, the belief that effective science teachers use diverse strategies was explicated by more preservice elementary teachers. In addition, one characteristic that emerged during the post-interview, which was not prevalent during the pre-interview, was that of flexibility. Conversely, engaging, a characteristic that was explicated during the pre-interview was not explicated during the post-interview.

For example, Jason stated, “An effective science teacher is flexible, knowledgeable, and open-minded.” Erika stated that, “embracing students in their diversity and [reflecting on] ‘How can I modify my lesson plan to pull this child in?’” became very important in determining a teacher’s effectiveness. Similarly, Sarah felt that
is was very important to be open. She commented that an effective science teacher should be “open to change definitely, flexible.” She goes on to elaborate that for her, being flexible involved a willingness “to sometimes let the students lead” the lessons. One possible explanation for the emergence of the characteristic of flexibility in preservice teachers’ post-responses is that by being in an authentic learning environment, i.e. working with the kids at the community center, they experienced the reality that sometimes lessons/activities do not go as planned and modifications must be made to meet students’ needs. The need to be flexible when implementing activities may have become more important than the need for effective science teachers to be engaging. This may explain why being engaging was not characteristic ascribed to effective science teachers during the post-interview.

In Section two, a teacher’s ability to engage the student was an important characteristic that emerged during the pre-interview. Natalia stated that an effective science teacher is “involving, engaging. For me they have to grasp my attention the minute I get there. If not, I’m lost.” Angel concurred by stating, “An effective science teacher would be one that makes the students enjoy science, makes them see the different ways you can do science in real life.” This characteristic also emerged as important during the post-interview, however it became more prevalent.

Two additional characteristics that emerged as important during the post-interview, which were not explicated during the pre-interview, were content knowledge and preparation. Natalia stated that it was important to “research the content” before hand in order to be “confident” when you’re speaking. Laura stated that teachers should “definitely be knowledgeable of the content…You should definitely know exactly what is...
true and offer facts.” In addition, both Natalia and Kim felt planning ahead of time was also important. The emergence of these characteristics may be explained by the fact that Instructor Roberts stressed the need for preservice teachers to know and understand the science content being discussed in order to effectively teach that content to their students. Knowledge of content was requisite if teachers were to effectively plan ahead.

In Section three, the ability to engage students was also emphasized during pre-interview sessions. Michael stated that it was important for “someone [to be able to] relate the things you learn to your life.” Kathy stated that effective science teachers needed to connect science “to the real world.” The same characteristic emerged as important during the post-interview. These results may be explained by Dr. Edwards continued emphasis on the need to understand children’s thinking patterns in order to foster curiosity.

A cross-comparison of post-interview data indicated the following: 1) Preservice teachers in Sections two and three believed that effective science teachers should be able to engage their students in the science content under discussion; 2) Preservice teachers in Sections one and two ascribed “knowledge of content” as an important characteristics of effective science teachers; 3) Preservice teachers in Section two perceived preparation as a characteristic of effective science teachers; and 4) Preservice teachers in Section one perceived effective science teachers as flexible and diverse. Similarities and differences will be discussed further in Chapter 5.

Creating a Learning Community

A learning environment that encourages student participation was an emerging theme across course sections. In addition to the use of hands-on activities, examples of
characteristics effective science teachers should possess in order to create a learning community included a caring attitude, patience, and enthusiasm. Preliminary interview data analysis indicated that preservice teachers in Section one thought that it was important for teachers to be enthusiastic or passionate about the subject of science. For example, Jason stated that effective science teachers “have to actually have some sort of excitement about the subject.” Sarah’s comments echoed this sentiment. She also felt that they should be “very passionate” about the subject. Preservice teachers believed that this enthusiasm/passion would encourage students to love science. Responses also suggest that preservice teachers believed that effective science teachers should use inquiry-based activities. More specifically, Jason commented, “They need to be a hands-on type of person because science, I don’t think, can be taught very well out of the book.”

During the post-interview, the following two characteristics emerged as important for effective science teachers to possess, caring and patient attitudes.

Erika stated that an effective science teacher has to reflect on what went right and what went wrong. An outcome of that reflective process may be the fact that, as a teacher, you “understand that ‘I was wrong in this, I’m sorry, how can we fix this.’” By acknowledging your imperfections, Erika suggested that this would show students that you really cared. Maria commented that as a result of the community-based service-learning experience, she began to understand the “home environment [of the kids] and that maybe they [weren’t] able to concentrate well because something happened at home and just being more aware of the kids’ situations and how it will eventually affect their productivity in the classroom.” Maria felt that being aware was a necessary step if teachers really wanted to create a safe and productive learning community for students.
Patience appeared as another characteristic of effectiveness. For instance, Maria goes on to mention, “Because even though throughout the lesson we would explain or talk about the subject and they still wouldn’t understand. So [I learned] to be more patient.” A possible explanation, as revealed by Maria’s statements, for the emergence of these characteristics, patience and caring, during the post-interview may be that since the community-based service-learning environment afforded preservice teachers an opportunity to interact directly with children, they began to recognize the importance of getting to know, and understand, who you are teaching. It is also worth noting that although using hands-on activities was an important characteristic of teacher effectiveness that emerged during the pre-interview, it became less important during the post-interview. A plausible explanation for this may be that since preservice teachers were required to implement hands-on activities every week with the children, it became more embedded in their pedagogical strategies and they no longer perceived using hands-on activities as a separate characteristic of science teacher effectiveness.

In Section two, based on preliminary data analysis, no characteristic emerged as particularly relevant for effective science teachers to possess. However, post-data analysis showed that the following characteristics emerged, a caring attitude and the use of hands-on activities. For instance, Natalia stated that effective science teachers understand their students. Angel posited that teaches could show that they care by allowing students to “feel like they’re creating something as well; that they have input.” Laura highlighted the need for effective science teachers to “pay attention to progression and the needs of [their] students.” She went on to say, “cause sometimes a student might
be asking for help, and subtly you notice that they’re slacking in one part of a certain area, so [you] definitely need to pay attention.”

Laura also emphasized the importance of allowing students to participate in hands-on activities during the post-interview session. She stated that effective teachers should “have children figure [problems] out for themselves.” This point was underscored by Kim who stated, “[effective science teachers] need to provide hands-on learning and be considerate of everybody in the classroom.” In other words, Kim felt that being considerate of students’ needs (i.e. providing hands-on experiences for those students who needed them) was an example of a teachers’ caring attitude. A possible explanation for the emergence of caring and the use of hands-on activities as characteristics of effective science teachers could be that many preservice teachers believed that Instructor Roberts, herself, modeled those characteristics during the semester. Post-questionnaire results strengthen this explanation. Preservice teachers indicated that instructor modeling positively influenced their beliefs in their ability to be effective science teachers.

In Section three, being enthusiastic emerged as a characteristic of effective science teachers during pre-interviews. For example, Eric stated that above all, “the one thing that separates an effective teacher from a mediocre teacher is the level of passion they bring into the classroom.” Robin concurred with Eric’s perspective on teacher effectiveness by stating, “passionate…because if a teacher is passionate about what they’re doing, it will reflect on their students.” Post-interview data analysis revealed the emergence of a new characteristic that preservice teachers believed effective science teachers should possess. Most preservice students also agreed that effective science teachers use hands-on activities to create a learning community. Eric commented that an
effective science teacher, after giving directions, “has to step back and allow the students to explore for themselves.” Robin vehemently emphasized that for her, the “number one thing would be hands-on learning.” She went on to state, “I’m a really big player in that I really believe that children learn best when they can physically manipulate objects and see what they’re doing.” Kathy agreed with Eric and Robin stating, “Hands-on. That like allows [for] self-exploration. Let them come to their own conclusion about things.” A plausible explanation for the emergence of the use of hands-on activities as a characteristic now being ascribed to effective science teachers would be that Instructor Edwards modeled the use of inquiry-based activities, within collaborative groups, with preservice teachers throughout the entire semester. Post-questionnaire results add corroborating evidence to the aforementioned explanation. Preservice teachers indicated that collaborative group work had the greatest effect on their beliefs in their ability to be effective science teachers.

A cross-comparison of post-interview data showed that preservice teachers in Sections one and two felt that in order to create a learning community, it was important that effective science teachers care about their students. However, for preservice teachers in Section two it was also important to allow students opportunities to participate in inquiry-based activities. The importance of effective teachers implementing inquiry-based science activities was also echoed by preservice teachers in Section three. However, the need for effective science teachers to possess a patient attitude was explicated more by preservice teachers in Section one. One plausible explanation for this difference could be due to the fact that the preservice teachers enrolled in Section one learned, from experience, that lesson plans are merely a template and are meant to be
modified. In addition, they may have learned that flexibility and patience, sometimes, go hand and hand.
Research Question 2

RQ2. What is the difference in the Personal Science Teaching Efficacy (PSTE) scores, and Science Teaching Outcome Expectancy (STOE) scores, among preservice elementary teachers enrolled in a community-based science methods course with an embedded service-learning component and those enrolled in two university-based science methods courses without an embedded service-learning component?

The Self-Efficacy Beliefs about Equitable Science Teaching and Learning (SEBEST) instrument was administered to preservice elementary teachers at the beginning and end of the Spring ’06 semester. The SEBEST consisted of 34 statements with 5-point Likert-scaled items. Choices ranged from strongly agree to strongly disagree. The SEBEST, which was modeled after the Science Teaching Efficacy Beliefs Instrument Form B (STEBI-B), encompassed two subscales, Personal Science Teaching Efficacy (PSTE) and Science Teaching Outcome Expectancy (STOE). Possible scores, on both subscales, ranged from 34 to 85. Ritter et al. (2001) reported that the SEBEST was a valid and reliable instrument. The internal consistency, Cronbach alpha reliability, for this research study was found to be 0.90 for the PSTE subscale and 0.91 for the STOE subscale. A sample SEBEST survey is included in Appendix A.

Although 72 participants completed the pretest, due to absences and withdrawals only 67 pretests had matching posttests. Since participants self-registered for science methods courses, the Levene’s test was applied to determine if the variances of the three study groups (Sections one, two, and three) were homogenous. The results of the Levene’s test, $F(2, 67) = 0.705, p > .05$ for PSTE and $F(2, 67) = 0.614, p > .05$ for STOE,
indicated that there were no statistically significant differences in the pretest score variance, at the 0.05 significance level, on both subscales, among the three study groups used in the study. These results indicated that the assumption of homogeneity of variances was not violated and there were no significant differences among the three groups before the semester began. Accordingly, it appeared reasonable to conduct the factorial ANOVA.

In order to answer this research question, the interaction effects were observed in two 3 x 2 Repeated-Measures Factorial ANOVAs run on SEBEST scores with course sections (community-based vs. two university-based) serving as a between subjects factor and time (pretest vs. posttest) serving as the within subjects factor. The interaction effect was seen as a comparison of the pretest and posttest scores within the groups being studied. If the improvement from pretest to posttest was greater in one group than in the others, an interaction effect would be present. However, if the improvement from pretest to posttest was not greater in one group than in the others, an interaction effect would not be present. The null hypothesis for this question was that there was no statistically significant difference in the PSTE and STOE means among preservice teachers in Sections one, two and three. Effect sizes are also reported. In ANOVA designs, measures of effect size (partial Eta squared ($\eta^2_p$)) are measures of the degree of association between an effect and dependent variable. For this study, the guidelines for evaluating Cohen’s effect size were that a value of 0.01 indicated a small effect, 0.06 indicated a moderate effect, and 0.14 indicated a large effect (Cohen, 1988; Gall, Borg, & Gall, 1996).
The results of the Repeated-Measures Factorial ANOVA for PSTE indicated a significant main effect for course section, \( F(2, 67) = 4.674, p = 0.013 \) (see Table 7), with a fairly large effect size (\( \eta^2 \)) of 0.127. Results also indicated that all three sections improved their scores from pretest to posttest. Section one increased from 72.045 to 79.045, Section two increased from 68.385 to 75.192, and Section three increased from 66.421 to 72.842 (see Table 8). The overall increase of the pretest (\( M = 68.950 \)) and posttest scores (\( M = 75.693 \)), without differentiating among course sections proved to be a significant increase at the 0.05 alpha level, \( F(1, 64) = 53.804, p = 0.000, \eta^2 = 0.457 \) (see Table 8). However, the ANOVA results showed a non-significant interaction effect between the pretest and posttest scores among course sections, \( F(2, 64) = 0.032, p = 0.969, \eta^2 = 0.001 \). Therefore, regardless of the pretest scores, or baseline, the three sections changed at similar magnitudes. This resulted in a non-significant interaction. These results indicated that there was not sufficient evidence to warrant rejection of the claim that the PSTE means among the three course sections were equal.
Table 7.

3 x 2 Factorial Repeated-Measures ANOVA for SEBEST PSTE Scores

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>Sum of Squares</th>
<th>Df</th>
<th>Mean Square</th>
<th>F</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Course Section</td>
<td>746.001</td>
<td>2</td>
<td>373.001</td>
<td>4.674*</td>
<td>0.013</td>
</tr>
<tr>
<td>PSTE</td>
<td>1498.386</td>
<td>1</td>
<td>1498.386</td>
<td>53.804*</td>
<td>0.000</td>
</tr>
<tr>
<td>PSTE * Course Section</td>
<td>1.755</td>
<td>2</td>
<td>0.877</td>
<td>0.032</td>
<td>0.969</td>
</tr>
<tr>
<td>Error (Course Section)</td>
<td>5106.924</td>
<td>64</td>
<td>79.796</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Error (PSTE)</td>
<td>1782.335</td>
<td>64</td>
<td>27.849</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>1500.141</td>
<td>66</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note. *p < .05

Table 8.

Mean PSTE Scores and STOE Scores on SEBEST

<table>
<thead>
<tr>
<th>PSTE</th>
<th>Pretest</th>
<th>Posttest</th>
<th>STOE</th>
<th>Pretest</th>
<th>Posttest</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Course Section</strong></td>
<td><strong>N</strong></td>
<td><strong>Mean</strong></td>
<td><strong>SD</strong></td>
<td><strong>Mean</strong></td>
<td><strong>SD</strong></td>
</tr>
<tr>
<td><strong>1</strong></td>
<td>22</td>
<td>72.045</td>
<td>7.937</td>
<td>79.045</td>
<td>7.273</td>
</tr>
<tr>
<td><strong>2</strong></td>
<td>26</td>
<td>68.384</td>
<td>6.165</td>
<td>75.192</td>
<td>6.530</td>
</tr>
<tr>
<td><strong>3</strong></td>
<td>19</td>
<td>66.421</td>
<td>8.681</td>
<td>72.842</td>
<td>7.755</td>
</tr>
</tbody>
</table>
The results of the Repeated-Measures Factorial ANOVA for Science Teaching Outcome Expectancy (STOE) indicated a non-significant main effect for course section, F(2, 64) = 1.805, p = 0.173, with a fairly moderate effect size of 0.053 (see Table 9). However, results showed a significant main effect for STOE scores. Means scores on the STOE increased from 78.818 to 81.864 for Section one, 78.269 to 80.308 for Section two, and 75.526 to 78.895 for Section three. The overall increase of the pretest (M = 77.538) and posttest scores (M = 80.355), without differentiating among course sections proved to be a significant increase, F(1, 64) = 14.296, p = 0.000, $\eta^2_p = 0.183$. However, there was no statistically significant difference in the interaction effect between the pre and posttest scores among the course sections, F(2, 64) = 0.305, p = 0.738, $\eta^2_p = 0.009$. These results indicated that there was not sufficient evidence to warrant rejection of the claim that the STOE means among the three course sections were equal.
Table 9.

3 x 2 Factorial Repeated-Measures ANOVA for SEBEST STOE Scores

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>Sum of Squares</th>
<th>Df</th>
<th>Mean Square</th>
<th>F</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Course Section</td>
<td>204.856</td>
<td>2</td>
<td>102.428</td>
<td>1.805</td>
<td>0.173</td>
</tr>
<tr>
<td>STOE</td>
<td>261.601</td>
<td>1</td>
<td>261.601</td>
<td>14.296*</td>
<td>0.000</td>
</tr>
<tr>
<td>STOE * Course Section</td>
<td>11.175</td>
<td>2</td>
<td>5.587</td>
<td>0.305</td>
<td>0.738</td>
</tr>
<tr>
<td>Error (Course Section)</td>
<td>3631.875</td>
<td>64</td>
<td>56.748</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Error (STOE)</td>
<td>11171.169</td>
<td>64</td>
<td>18.300</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>272.776</td>
<td>66</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note. *p < .05

Research Question 3

*RQ3*: What science methods course experiences, if any, are identified by preservice elementary teachers as having a positive effect on the development of their self-efficacy beliefs concerning equitable science teaching?

Results from the post-questionnaire were used to answer research question three. There were eight experiences listed for participants to evaluate. The perceived effect of these experiences on preservice elementary teachers’ science teaching efficacy regarding equitable science teaching and learning was rated from negative (1) to positive (5) for each course experience. The results are presented in Table 10.
Section one evaluated the field experiences at the community center as having the most positive effect on their ability to teach science to diverse populations. Working in cooperative groups and feedback from the methods instructor were also rated as having somewhat of a positive effect on their ability to teach science. Section two evaluated feedback from the science methods instructor as having the most positive effect on their ability to teach science to diverse populations. Similarly, methods course assignments, methods course readings, the methods course instructor, cooperative group work, and the modeling of science lessons by the methods instructor were all rated as having somewhat of a positive effect on their ability to teach science. Section three evaluated cooperative group work assignments/activities as having the most positive effect on their ability to teach science to diverse populations. The methods course instructor and feedback from the methods course instructor also had somewhat of a positive effect on preservice teachers’ science teaching efficacy about equitable science teaching.
Table 10.

Science Methods Course Experience Means

<table>
<thead>
<tr>
<th>Experiences by Course Section</th>
<th>1</th>
<th>2</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>SD</td>
<td>Mean</td>
</tr>
<tr>
<td>Methods course assignments</td>
<td>3.83</td>
<td>0.80</td>
<td>4.54</td>
</tr>
<tr>
<td>Methods course readings</td>
<td>3.29</td>
<td>0.99</td>
<td>4.23</td>
</tr>
<tr>
<td>Methods Textbook</td>
<td>n/a*</td>
<td>n/a*</td>
<td>n/a*</td>
</tr>
<tr>
<td>Methods Instructor</td>
<td>3.92</td>
<td>1.16</td>
<td>4.58</td>
</tr>
<tr>
<td>Cooperative Group Work</td>
<td>4.30</td>
<td>0.86</td>
<td>4.42</td>
</tr>
<tr>
<td>Field Experiences</td>
<td>4.63</td>
<td>0.39</td>
<td>n/a*</td>
</tr>
<tr>
<td>(tutoring, field observations, student interviews)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Feedback from methods instructor</td>
<td>4.08</td>
<td>0.81</td>
<td>4.62</td>
</tr>
<tr>
<td>Instructor modeling science lessons</td>
<td>3.67</td>
<td>1.47</td>
<td>4.54</td>
</tr>
</tbody>
</table>

*Not used in this course

Open-ended questions were also utilized in the questionnaire to gain further insight into course experiences which either positively or negatively affected preservice teacher’s beliefs in their ability to be effective science teachers of diverse student populations. Responses to these questions were read and coded. Coded responses were
sorted and categorized to find major patterns. Themes were not consistent across course sections. Therefore, the themes that emerged for each section will be presented separately.

Section one. Section one, which was taught by Instructor Roberts, cited specific experiences at the community center which positively and negatively affected their science teaching efficacy. Two themes emerged from their responses: authentic experiences with diversity and eye opening experiences with diversity

Authentic Experiences with Diversity

Many preservice teachers have limited cross-cultural experiences with individuals whose sociocultural backgrounds may be different from themselves. This service-learning experience allowed some preservice teachers to identify with the phrase “never judge a book by its cover.” Some preservice teachers commented that the mere exposure to children of different racial and ethnic backgrounds helped them to understand “first hand how diverse students learn.” For example, the following comments were made by preservice teachers regarding how their service-learning experience helped them to understand diversity:

The chance to work with students from different racial/ethnic backgrounds than my own [has] given me a chance to learn about each child’s background, culture, and to see that there are differences to adapt to.

Actually encountering students from all SES groups has helped me to understand their differences.

Getting to know the kids, their interests, as well as their dislikes [has positively impacted my ability to teach science to kids from different SES backgrounds]. I’ve had more experience in the community center than I have had in my past. We had a little girl who was always dirty and lacking hygiene. She lived in a poorer part of [the city]. She was a brilliant student. This dispelled the attitude I had about poor students.
Furthermore, to summarize her experiences, one preservice teacher indicated that her confidence had increased because she experienced “love from the kids.”

However, not all of the experiences encountered by preservice teachers positively influenced their self-efficacy beliefs. Two preservice teachers stated that some of their experiences at the community center had a negative effect on their ability to teach science to diverse students. For instance, one preservice teacher commented that students were unmotivated and that it was hard to keep them on task. While another student made the following statement, “Since we had 5 racial/ethnic minorities in our group, much of the time the group was loud and inattentive.” She went on to say, “I am not saying that Caucasian students are not like this either.” However, if she really believed that all students were like that, would she have made the comment in the first place? This comment leads one to question whether or not this experience reinforced the negative beliefs she already possessed about diverse student groups.

Eye Opening

Many preservice teachers believe that they are “open-minded.” However, when exposed to diversity, they quickly realize that they may possess “dysconscious” beliefs about students from diverse racial/ethnic backgrounds and low income students which may limit a student’s opportunity to learn. Preservice teachers may hold on to these “dysconscious” perceptions until they are provided with experiences that challenge them. For some preservice teachers, this service-learning experience did just that. It challenged the preconceived beliefs they possessed about urban students. The following statements were made by a few preservice teachers on their post-questionnaire regarding their eye-opening experiences:
Having the experience of the community center has definitely opened my eyes to diverse communities. Working with the kids was a big positive.

[This experience allowed me to] break through and figure out the stereotypes that I have regarding some cultures.

This experience has enlightened me as to what I believe and what I feel my preconceived notions were when I came in the class first. Now my attitude has changed.

I think as a future educator my awareness has been heightened. This is a very important aspect because once you become aware you will be able to proactively change expectations.

Section two. In section two, also taught by Instructor Roberts, diversity assignments, which included personal narratives, readings and discussions, were listed as additional experiences that positively affected preservice teachers’ beliefs about their ability to teach diverse students. Based on their answers, the following themes emerged: developing self-awareness, hearing the “Other’s” voice, and feedback helps.

**Developing Self-Awareness**

This course has helped me become aware.

[The] personal diversity narrative was an excellent means to examine my own prejudices.

The abovementioned statements are examples of feelings expressed by preservice teachers regarding the development of self-awareness. An important outcome of this science methods course was that some preservice teachers learned to critically reflect on their beliefs and attitudes. The autobiographical narrative assignment along with the diversity readings and discussions challenged preservice teachers to 1) think deeply about their embedded beliefs regarding diversity; and 2) understand how these beliefs are translated into behaviors that marginalize diverse students. Preservice teachers commented that the autobiographical narrative paper helped them to examine their own
experiences and the experiences of others. Other preservice teachers indicated that the diversity readings and discussions helped them to really take an honest look at themselves and their behaviors. For example, a female preservice teacher came to the following conclusion when asked how experiences in the science methods course would help her career, if at all, as an elementary science teacher of diverse populations: “The class discussions we had and the papers we read, *Silence Dialogue* and *White Privilege*, as well as the multicultural awareness quiz were all enlightening. They furthered my determination to teach effectively to all my students.”

*Hearing the “Other’s” voice*

During the diversity discussions, there was always one person who remained silent. That person was Angel, “the only obvious minority” as she put it. Angel chose to remain silent during discussions related to the inequalities and inequities experienced by ethnic minorities and those from poor backgrounds due to the fact that she believed that her voice would be interpreted as the voice of all African Americans. In addition, because she was upset about the comments some of her peers were making, she didn’t want to come across as the “angry black person.” She felt that some of her peers chose to ignore the inequities that exist within American society.

A few students commented in their reflections that they would have liked to hear what she thought about the diversity issues being discussed in the course. Therefore, Instructor Roberts asked Angel if she could read her reflection to the class because it was within those reflections that Angel shared how she really felt about 1) listening to her peers and 2) being an ethnic minority from a low-income household. After much consideration, Angel allowed Instructor Roberts to read the reflection to the class. This
reflection was listed by some preservice teachers as an additional experience that had a positive effect on their ability to teach science to diverse populations.

Feedback Helps

Verbal persuasion is one of the four sources of efficacy listed by Bandura (1992) as having either a positive or negative effect on one’s self-efficacy. In Section two, the words of encouragement, and/or the constructive criticism, given by the instructor and peers regarding preservice teachers’ mini-lessons, were listed as having a positive effect on preservice elementary teachers’ personal science teaching efficacy. Some preservice teachers indicated that the feedback that was given to them by the instructor and their peers was “invaluable.” In addition, it helped them to develop “new ideas and new activities.” There were no experiences listed as having a negative effect on their ability to teach science to diverse populations.

Section three. When asked about additional experiences that affected their ability to teach science to diverse populations, one theme emerged from the responses of preservice teachers, diversity within collaborative groups.

Diversity within Collaborative Groups

A few preservice teachers indicated that the experiences they had working with their group members when experimenting positively affected their ability to teach science to diverse students. For example, a male preservice teacher stated, “just working with classmates from different collaborating backgrounds than my own has given me the insight to what [I] will expect from my kids.” Preservice teachers did not list any course experiences that had a negative effect on their ability to teach science to diverse populations.
Research Question 4

RQ4. How do preservice elementary teachers’ beliefs about multicultural science teaching change, if at all, over the course of a semester?

A teacher’s confidence in his or her perceived ability to be effective teachers of all students may also depend on their beliefs about equitable science teaching, commonly referred to as multicultural science teaching (Atwater, 1993, 2000). Multicultural science teachers strive for equity. That is to say, they strive to treat students fairly by taking into account differences. To investigate preservice elementary teachers’ beliefs about multicultural science teaching, the following questions were posed during pre- and post-interview sessions:

1. How would you define multicultural science teaching?
2. What does equity mean when teaching science?
3. How, if at all, will your students’ racial/ethnic backgrounds affect on your science teaching?
4. How, if at all, will your students’ social class backgrounds affect your science teaching?
5. How, if at all, will your students’ language backgrounds affect your science teaching?
6. How, if at all, will your students’ cultural backgrounds affect your science teaching?

However, responses to question three proved to be problematic due to the fact that many preservice teachers failed to differentiate, either consciously or unconsciously, the term
race/ethnicity from language and/or cultural backgrounds. In other words, many preservice teachers seemed to believe the term race/ethnicity was synonymous with the term culture and/or language. For example, when asked what effect students’ racial backgrounds would have on their science teachers, many preservice teachers would refer students’ cultural or language backgrounds in their answers. So, for the purposes of this study, responses to question three were not analyzed. Constant comparative analysis of the remaining responses yielded the following themes: building blocks to multicultural science teaching and barriers to multicultural science teaching (see Figure 8). However, before discussing the themes, a general overview of the course environment that developed during one of the diversity discussions will be presented first.

Figure 8. Beliefs about Multicultural Science Teaching
Course Environment: Embracing and Resisting Diversity

Issues related to diversity were touched upon in all sections. Instructor Roberts used three course sessions to explicitly address diversity. For the purposes of this study, a course session was considered to encompass a preponderance of the course’s scheduled time. However, only one of those sessions made an explicit connection between diversity and science teaching. The other two sessions simply addressed issues of diversity, with no connection being made between diversity and science.

Instructor Edwards used one course session to explicitly discuss issues related to diversity and science teaching. As a matter of fact, both instructors used the same activity at the beginning of the semester, the Draw-A-Scientist Test (DAST), to make an explicit connection between diversity and science. The following description of the DAST activity is related to the procedure used by Instructor Edwards.

Preservice teachers were asked to visualize their perception of a scientist and transfer this image to paper. They were then instructed to get into groups with people with whom they were not familiar. Each person explained what they were thinking as they drew their scientist. They also discussed the similarities and differences observed between the drawings. Stereotypical images of scientists dominated the drawings; that is a white male with crazy hair, wearing glasses, and holding a beaker (or test tube) in a lab. Moreover, scientists of color were not presented in any of the drawings. Although the identical procedure was not followed by Instructor Roberts, the aforementioned characteristics also dominated the images drawn of scientists by preservice teachers in her science methods courses. The stereotypes that dominated the images of preservice
teachers’ depictions of scientists were typical and a discussion of them will not add to the existing knowledge base (Finson, 2001).

Instructor Edwards proceeded to ask the students to discuss why they believed their images were void of diversity. Some students blamed the media for the hegemonic portrayals shown on television, while others stated that, historically, men had access to educational opportunities that were otherwise inaccessible to women. The question of “What would happen if you were a kid and an image like this came to mind?” was then posed to students. Many commented that if a child was female, or any race other than white, he or she would not be able to perceive themselves as scientists because they didn’t see people like themselves being represented as scientists in textbooks and/or on television. Students were finally asked to think about what they, as teachers, could do to help all kids “think that they can do science.” Comments included integrating hands-on activities into the curriculum, making real-life connections between science and students, and informing children of the different contributions of males and females to the scientific enterprise.

As a follow-up activity, students were asked to choose a non-stereotypical scientist and present his or her scientist’s biography. This was the only explicit discussion observed with preservice teachers about the importance of diversity in the science curriculum throughout the semester. The narrative that is presented below is based on a diversity discussion that took place in both of Instructor Roberts’ courses.

Section one. During the fifth week of classes, the discussion began with an open-ended question regarding Delpit’s article *The Silenced Dialogue*. This article talked about the culture of power and how this culture must be explicitly conveyed to ethnic
minorities. The preservice teachers did not respond to the open-ended question and it took quite some time to get input from anyone in the class. This could have been due to the fact that they had not read the article or were just uncomfortable and/or hesitant in talking about the topic at hand. If students did not feel comfortable responding verbally in class, they were given the option of responding via email. If students did not respond to the topic, either verbally or via email, points were subtracted from their class participation grade for the day.

Three groups of preservice teachers emerged during the discussion. The first group felt that it was unnecessary to address issues related to diversity because as teachers, they would treat all children the same. The second group felt that people from other cultures should assimilate into the American culture. Furthermore, if these individuals chose not to assimilate, they should leave the country. This perspective was underscored when Jason, a white male, explicated “Why do we have to cater to them?” Jason was referring to the fact that if a person were to travel to Japan, no one in Japan would change their behavior for Americans. Therefore, as Americans, why must we change our behaviors for them? This sentiment was echoed by others in the class.

In an effort to help them think more deeply about the issue, Instructor Roberts asked the preservice teachers about Native Americans who were here before the Europeans and the African Americans who have been here since the inception of this country. Should they be forced to conform or leave as well? The students had very little response to this question. They simply thought that it was not a big deal and even Native Americans and African Americans were not that different. They reiterated the belief that everyone should be treated the same. Furthermore, they felt that too many of their
classes were spending too much time on diversity and they registered for this class to learn how to teach science, not to address diversity issues. The last group understood that every individual’s background was unique and could relate to Delpit’s argument for teachers to 1) explicitly address differences; 2) make personal connections with their students; and 3) relate the school curriculum to students’ lived experiences.

McIntosh’s (1993) article, *White Privilege: Unpacking the Invisible Knapsack*, was met with the same dichotomy, resistance and acceptance. However, by this time, preservice teachers were much stronger in voicing their disagreement. As a matter of fact, some were quite insulted by the implication that white people had more power in American society and refused to look at the list McIntosh presented in the article. During the discussion of the two articles, I noticed that Erika, the only African American female in the class, did not participate. I met with her later that week to ask her why she chose to remain silent. Her response was as follows:

> Like someone once told me…well like the Bible says. You can’t throw pearls to swine you know. I don’t know. I just feel like…it’s not pointless because to plant a seed is important…I guess it’s like pointless because I feel like the biggest thing to change is somebody’s mindset.

Erika’s perception of the conversation was that her peers were saying that minorities in America, herself included, should not expect teachers or Americans to adjust their pedagogy to meet their needs. She went on to say, “To me it was hurtful hearing that because in my mind, I was just like these are the future teachers of America…and that’s why [our state] is [close to the bottom when it comes to] education.” She was extremely disheartened by the outcome of the discussion and felt that her peers did not care to hear any other point of view. However, Erika realized that she played a part in perpetuating the aforementioned views of her peers by not speaking
up. This was highlighted when she stated, “And it was my bad too. My mistake because I didn’t say anything. I kept quite the whole time you know and stuff.” Erika didn’t speak up because after hearing people question the need to “cater” to minorities, she was angry and didn’t want to show her peers that their comments were affecting her in a negative manner.

Section two. The first half of the fifth class session was used to address issues related to diversity. Because the discussion on White Privilege was not well-received during the diversity discussion in Section one, Instructor Roberts decided not to address that specific article with this section. Instead, this session was used to discuss the Multicultural Education and Equity Quiz and Delpit’s Silenced Dialogue. As Instructor Roberts went over the answers to the questions to the multicultural quiz, preservice teachers were shocked by some of the facts. For example, some indicated that they had no idea that family income and SAT scores were interrelated. In addition, preservice teachers were surprised to find out that a lot of the toxic waste dumps were located in low income areas. However, when looking at the discrepancies that existed between low income and high income families, preservice teachers felt that race did not factor into the equation. After reviewing the answers to the quiz, Instructor Roberts introduced Deplit’s article.

She began by explaining to the class that we have a dominant culture in American society and that those in power have certain expectations and assumptions. She then asked preservice teachers to talk about how issues of power may be enacted in the classroom. More questions followed such as, “What is the culture of power and some of the rules that follow this culture?” and “Who makes the rules in our society?” Preservice
teachers referred back to their K-12 school experiences and how their teachers treated them. A preservice teacher commented that “if all teachers made all their students feel like they were achievers then the students could do it and become successful.” They also shared some of their experiences with being stereotyped and the discriminatory practices they saw being exhibited by co-workers and friends. However, some students remained silent during the entire discussion. More specifically, Angel, the only African American student present during the discussion, refused to participate and looked aggravated during the entire discussion. There were many instances where I observed Angel “cutting” her eyes as her peers told their stories of discrimination. This could have been due to the fact that those who chose to share their stories were white females and Angel questioned whether they really understood what being stereotyped and discriminated against really felt like. Instead of making this assumption, I decided to ask her why she chose to remain silent during the class discussion.

Although my assumption was correct, Angel also questioned the purpose of tying diversity, black students as she perceived it, into a science methods course. As she reflected a little more, she stated that she understood the importance of exposing teachers to issues related to diversity. However, Angel was hesitant in expressing her views because she felt that since she was the only African American in the class, everyone would be looking to her as the voice of all African Americans. She stated, “I’m the black person. And…before I speak or say anything, I’m going to critique my thought or what I’m about to say, cause I cannot sound stupid…I’m representing the black people here.” In addition, she felt that the class discussions centered too much on the negative factors
that were associated with people of color and did not represent a balanced view. This point is underscored by the following comment made by Angel:

I’m saying at the same time, it makes me angry because it’s kind of a shame in a sense. Like dang, why do you have to let them know that we are at the bottom? How come they have to know that 65% of schools for Hispanics and Blacks are near a toxic waste dump? Now they have...I feel like they have something they can throw in our face.

She went on to say that the discussion made her feel bad about the person she was and reminded her of the way she felt during Black History month. Even though Angel didn’t enjoy the discussion on diversity, she did feel like the class was “open-minded.” However she questioned whether or not they really understood the issue at hand. She criticized her peers for their ignorance. Towards the end of our discussion, Angel commented:

Certain people were talking about certain things and I’m like look girl, we’re talking about a way deeper issue...This one girl shared about her being pregnant and people looking at her differently. I mean I understand how you could connect it, but I felt like we were talking about something different.

She admitted that her reasons for staying silent were underpinned by the presuppositions she possessed about her peers. She assumed that some of her peers just “didn’t get it and didn’t understand” because they did not want to understand. However, when Instructor Roberts reflected on the reflections the following week, a couple of preservice teachers were interested in what she had to say and wondered how she felt about the topic at hand.

There may be several reasons that explain why the diversity discussion was well-received by one section but not the other. One of those reasons may be due to the fact that Instructor Roberts eliminated McIntosh’s *White Privilege* article from the diversity discussion in Section two. Another possible explanation could be that if preservice teachers in Section one acknowledged the inequities that exist between Whites and
people of color, they may not have been able to function as well in this community-based service-learning environment. Perhaps it was too much for them to confront their “dysconscious” perceptions of diversity while teaching diverse students at the same time. The next two sections will discuss the two themes that emerged from the interview analysis: building blocks to multicultural science teaching and barriers to multicultural science teaching. The quotes that are presented below do not capture every participant’s response, but they do provide evidence to support the aforementioned themes. Additional interview excerpts can be found in Appendices E, F, and G.

Building Blocks to Multicultural Science Teaching

Efficacious teachers use didactic instructional methods (Tschannen-Moran, Hoy, & Hoy, 1998) in order to equip students with the skills they will need in order to become scientifically literate. Furthermore, they use students’ differences as building blocks to enrich their curriculum and to provide fair and equitable learning opportunities. In this study, building blocks to multicultural science teaching included 1) preservice teachers’ transformative definitions of multicultural or equitable science teaching and 2) preservice teachers’ abilities to adjust their pedagogical practices, taking into account differences in students’ social class, language, or cultural backgrounds (multicultural pedagogy).

Transformative Definitions. The excerpts below have been taken from individuals displaying definitions of multicultural and/or equitable science teaching, which include acknowledging, respecting, and using differences (e.g. sociocultural backgrounds, learning styles, learning abilities) to enrich the science curriculum and pedagogical practices.
Maria (Section one): [Multicultural science teaching means] incorporating different diverse and different cultures of science. And activities that involve different learning levels.

When asked to explain the interrelatedness of equity and science teaching, Maria went on to state that equity meant being fair to all students. When asked what fairness would look like in action, she stated:

I would make sure that my lessons or that my students were challenged…hopefully I will know my students well enough to see where their learning abilities are. So, I would try to build on that and be fair with all of my students in that aspect.

The responses Maria gave during the post-interview diverged from her pre-interview responses. For example, Maria’s initial description of multicultural science teaching was “presenting students with scientists or people that are all from diverse cultures.”

Erika (Section one): [Equity in science teaching] means to be equal across the board.

When asked to explain what she meant by equal across the board, Erika stated:

If I have an Indian student, an African student and an American student in all my classes, the way I present the material will be in a way that accommodates [italics added] all of my students…I’m not just catering [italics added] to the American student since I’m American.

As opposed to simply presenting different scientists, the belief explicated at the beginning of the semester, Erika now felt the need to accommodate the differences students bring into the science classroom. These differences included diverse ways of knowing and learning. Erika also made a similar comment towards the end of the semester in front of her peers when she was asked by the instructor to mention one insight she gained from her course experiences. She verbally explicated this view to the class in response to the comments some of her peers made during the diversity discussion about their unwillingness to cater to diverse students. She was bothered by the fact that
she didn’t speak up during the discussion and wanted her peers to know that effective science teachers adjust their pedagogy to meet the needs of their students and that this should not be considered as “catering” to one group. When asked to define multicultural science teaching during her pre-interview, Erika stated that it was “teaching to different modalities.” However, during her post-interview, multicultural science teaching was defined as:

Breaking down stereotypes…teaching to everybody and not feeling like this group will do more and this group less…when someone says ‘What’s the first thing you think of when you hear the word science or scientists’ and everybody writes black, white, female…when everyone gets to that point, I feel that’s when we’ll have it.

Erika started off the semester with the belief that science was culture free; that is, science didn’t have a color, face, or gender. However, based on her experiences in the course, she began to recognize the interconnectedness of diversity and science. Although she still believed that it was important use tap into students’ modalities, it became just as important to provide diverse student groups with images that depicted their sociocultural backgrounds.

Jason (Section one) started off the semester believing that equity was related to a quantity. For example, he stated that equity was “how much time you spend on a lesson, how much planning, how much excitement, how much personal belief.” During the post-interview, Jason made the following statement regarding equity:

Equity in science is how much information you put into a science lesson. How accurate it is. If it’s not accurate, it’s not worth very much. Equity is worth. How much the lesson is actually worth to the students, how much they got out of it. You got to put effort into it to get effort out.

At the end of the semester, the word equity became more than a number. It became synonymous with the term worth. Although it remained important for teachers to
consider the amount of effort they put into the lesson, it also became important for
teachers to consider how much students were getting out of the lesson; that is, what were
the students actually learning.

- Natalia (Section two): I would probably define it [multicultural science teaching]
as…You have to be aware of the people’s culture and be able to respect and know
how to engage your students. If [I had] a classroom for example of Hispanic
students, I may teach them with something in Texas for example, in North
Mexico. We have a pig that they call the Havelina. I think it’s a boar, but they
call them Havelina. So, maybe I would say ‘Today we’re going to learn about a
Havelina’ and then say ‘this is a boar. It’s a wild pig’ and elaborate on that.

As opposed to her initial definition of multicultural science teaching given during the pre-
interview, “not having one culture dominate the subject,” Natalia’s understanding of
multicultural science evolved and she began to comprehend the importance of being
aware of culturally familiar objects and using that awareness to make science come alive.

- Laura (Section two): I think it reminds me of when we drew what we think of
when we think of a scientist. A lot of the class drew Einstein…So, I just think
[multicultural science teaching is] offering a wide variety of diversity, diverse
people…I would [also] have students work together because if there were three
Caucasians, they’re not the same people. They’re still diverse. They have three
different cultures. I would try my hardest to show different perspectives cause
they are the learner. They’re the researcher. And definitely show them that
they’re all capable.

The excerpt above represents Laura’s post-response to defining multicultural science
teaching. However, during her pre-interview, Laura stated that multicultural science
teaching was “offering different types of learning styles…whether it’s for an auditory
learner of visual learner.” Although both of her responses affirmed students’ diverse
backgrounds, by the end of the semester, Laura indicated that multicultural science
teaching included more than using students’ diverse learning styles. She stated that
students must also be shown diverse scientists and provided with opportunities to interact
with diverse students.
When asked to explain what equity meant when teaching science, Laura’s response was similar. She emphasized the need to show students that “everyone’s ideas are important and add to what we’re learning and talking about.” This perspective diverged from her pre-interview description of equity in science teaching; that of “using numbers effectively whether it be the number of trials you do an experiment; the time you would use, the time limit for each experiment or group number.” Throughout the post-interview, Laura explicated the importance of hearing the diverse perspectives of other group members. To her, it was important for students and teachers to realize that their way may not be the only way, or the correct way.

- Michael (Section three): [I would describe multicultural science teaching as] making adaptations for all the students. Taking into account all the cultures and everything that goes along with that and giving them an equal opportunity at one education. I think you can incorporate multicultural education into normal things. Like learning at the lab, having different learning centers. Having the kids interact I think is the best way.

During the pre-interview, Michael indicated that students should “feel a part of the same culture…the American culture.” Michael expanded his definition of multicultural science teaching from an assimilationist perspective of conforming to one culture to that of adapting his instructional style to meet student needs.

- Robin (Section three): [Equity in science teaching means] providing the same opportunities for all students.

When asked how she would go about providing the same opportunities for all students, she said:

Making sure you have, that you make changes where needed. If you have a physically disabled student who’s in a wheel chair, you’d want a table high enough where they can sit underneath it; make accommodations.
Robin’s view of equitable science teaching changed from “I don’t know,” the response she gave during the pre-interview, to her recognizing that in order to provide some students with equal opportunities to learn, teachers must first make accommodations to fit the learning needs of their students. She used the aforementioned example because that was the chapter she was required to read in the textbook. Chapter presentations were part of the course syllabus. Robin internalized that information and applied it to equitable science teaching.

Although most of the responses were similar across course sections, it is worth noting that all of the preservice teachers interviewed in Section one either changed, or expanded, their descriptions of equity in science teaching to include concepts of fairness. One possible explanation for the insight gained by preservice teachers in all sections may be that since both instructors utilized the Draw-A-Scientist Test (DAST) to reveal preservice teachers presuppositions about what science is and who is a scientist, preservice teachers became more aware of the inequalities and inequities that exist within science education. Furthermore, since preservice teachers in Section one were placed in a multicultural environment which perhaps challenged their preconceived notions of equitable science teaching, they accommodated new perspectives of equity based on their service-learning experience.

**Multicultural Pedagogy.** Preliminary data analysis revealed that some preservice teachers entered their methods courses with beliefs that may serve as barriers to multicultural science teaching. However, by the end of the semester, these beliefs became culturally affirming. That is to say that some preservice teachers began to take into account how student differences may positively affect their science teaching. There
were also preservice teachers who consistently, from the beginning to the end of the semester, explicated pedagogical beliefs which affirmed students’ diverse backgrounds. Table 11 gives sample interview excerpts of changes and consistencies in pedagogical beliefs that take into account student differences. The category “change” represents pedagogical beliefs that changed from a limiting pedagogy to a multicultural pedagogy. The category “consistent” represents pedagogical beliefs that remained at the multicultural level from the beginning of the semester to the end of the semester.
<table>
<thead>
<tr>
<th>Pedagogical Beliefs</th>
<th>Pre</th>
<th>Post</th>
</tr>
</thead>
<tbody>
<tr>
<td>Change</td>
<td>[Students’ backgrounds] wouldn’t affect my science teaching</td>
<td>I would just use everything that I’m learning in my ESOL classes…Just using pictures and ways of communicating with them.</td>
</tr>
<tr>
<td>Change</td>
<td>I don’t think [students’ cultural backgrounds] would [affect my science teaching]</td>
<td>Students from different cultures see lots of different things. Like a student from China wouldn’t have any idea of what a red-tailed hawk looks like cause they’re not native to China…I’d try to incorporate their culture into the lesson somehow where they feel like their culture is appreciated and it does connect to ours in a lot of ways.</td>
</tr>
<tr>
<td>Consistent</td>
<td>If [students] don’t have science vocabulary that will be really hard to teach. So, you would have to break it down…explaining what the different things are you’re talking about so that you’re not over their heads the entire time</td>
<td>I think [students’ language backgrounds] will affect it a lot. Because if you do have students who don’t speak English proficiently, then you need to maybe not give them a textbook…Give them pictures instead of forcing them to read a textbook</td>
</tr>
<tr>
<td>Consistent</td>
<td>[Students’ cultural backgrounds] would affect it in the planning…everybody came from somewhere so you want to try and include their cultural backgrounds in the lessons. It’ all about tapping into prior knowledge</td>
<td>[Students’ cultural backgrounds] will influence it in what background I put into a lesson. Like if a student came from one country, I would incorporate their customs into the lesson, so basically every student can learn about where they came from. So, they can understand what that student is going through</td>
</tr>
</tbody>
</table>

Maria (Section one) started off the semester stating that students’ social class and cultural backgrounds would not affect her science teaching. However, at the end of the semester, Maria made the following comments:
If the lesson requires for the students to bring in materials and I know that the family is struggling economically, I probably would limit, try to limit those types of lessons where it requires the students to bring in those materials. I would try to recycle throughout the year and have those materials available for those that aren’t able to bring them in…I guess I would want to be able to incorporate people of different cultures that have come up with different subjects areas or different ideas and just try to incorporate, so that every culture is touched in my classroom.

As indicated above, Maria’s pre- and post-interview statements diverged. Not only did Maria acknowledge how students’ social class backgrounds may affect her science teaching, she articulated strategies (i.e. recycling) that could be used to make resources available to students. Similarly, instead of ignoring students’ cultural backgrounds, Maria articulated the need to come up with strategies that incorporate students’ cultural backgrounds into the curriculum.

Jason (Section one) struggled with the effect of students’ social class backgrounds on science teaching. During his interviews and course discussions, he always stated teachers should always focus on the “individual” person. For Jason, the individual person was disconnected from their sociocultural background and teachers should focus on students’ intelligences (i.e. multiple intelligences). He initially stated that since lessons should be “geared to all types of students, their economic level shouldn’t matter.” When asked what he meant by all types of students, Jason referred to their method of learning. At the end of the semester, Jason stated:

It really shouldn’t. But, if you’re assigning homework, it depends on their social background. Like if they don’t have a computer in the home, you really can’t assign them to do an internet assignment at home. It depends on…it’s not really their social [class] background. It’s what they actually have and what they don’t have.

The post-interview reveals Jason’s continued struggle with understanding how students’ social class backgrounds may affect science teaching. However, as he analyzed his
beliefs, he began to reason how social class may affect the availability of resources to
students at home. To account for this lack of availability, Jason’s group brought in a
laptop computer for one of their science activities at the community center.

Angel (Section two) possessed the same views at the beginning of the semester
about the effect of social class backgrounds on her science teaching. However, she also
internalized the statement and applied it to her life experiences. Angel assumed that her
social class status would limit her ability to teach science. She stated:

[My social class background] would probably limit science. Because it’s a lot of
things about science I don’t know. I feel like because of my experiences, I feel
very limited.

Although Angel recognized that her social class status has limited what she has been
allowed to experience, she went on to say, “Now I have control and I can do what I want
to do.” Therefore, Angel has decided to work at an inner city school when she graduates
to help students, like her, reach their potential. At the end of the semester, when she was
asked how students’ social class backgrounds would affect her science teaching, she
commented:

I want to teach at an inner city school and I feel like I’m going to provide
everything that I possibly can and if they ever have to purchase anything and
can’t, they will always be able to come to me and just let me know. I don’t even
think I’m gong to ask them to purchase anything. I think I will mostly provide
whatever I can…

Michael (Section three) also had the same views about the effect of students’ social class
backgrounds on science teaching toward the beginning of the semester. He felt that it
wouldn’t have any affect because all students can learn. However, when asked the same
question at the end of the semester, Michael’s response showed that he really began to
critically examine his preconceived notions of the interrelatedness of students’ social class backgrounds and science teaching. During his post-interview, Michael stated:

Well generally, poorer students don’t have the background knowledge and experiences that some of the wealthier students do. So, they’re going to bring different things in. Maybe some poor kids won’t have half the things that wealthy kids have, or won’t be taught. Most of their parents work or they don’t have parents that can help them with homework.

When asked what effect these external factors would have on his science teaching, Michael elaborated:

I’d just have to find a way to get them all on the same levels. Or at least bring the kids who don’t have those experiences some of those experiences and give them that background knowledge. I think a good way to [accomplish this] may be to go somewhere that none of them have been, so they’re all at the same point.

The majority of changes that took place in relation to the interconnectedness of students’ social class, language, and culture backgrounds and science teaching took place at the social class level. A possible explanation for this result could be that preservice teachers began to understand that a student’s schemata may vary based on the experiences he or she has had, which is dependent on their social class backgrounds.

Many preservice teachers consistently responded in the same manner, from the beginning to the end of the semester, when they were asked about the effect students’ language backgrounds would have on their science teaching. They felt that it was very important to make adaptations for ESOL students. For example, Laura (Section two) stated at the beginning of the semester that she would give more examples and use more gestures to get ESOL students to understand science concepts. At the end of the semester, the same view was echoed. However, she also stated the following:

I really want to brush up on languages. I’ve taken ESOL 1 and will be taking ESOL 2 this summer, and I think that will help, just learning different ways to get them to understand certain ideas. Whether it’s with pictures or acting it out or
working with other students that are English proficient. I think it’s very important cause they’re in our classroom and will be going out into the real world. So, it’s here in the classroom where they need to learn

During Sarah’s (Section one) post-interview, she stated the following:

I think it can affect it a lot. Because if you do have students who don’t speak English proficiently, then you need to maybe not give them a textbook or give them a dictionary of words that they might encounter. Give them pictures instead of forcing them to read a textbook that they don’t even understand half the words in.

This answer did not deviate from the response she gave at the beginning of the semester where she also explicated the importance of “breaking down science vocabulary” and providing more explanations.

Natalia (Section two) stated that it was important to “have the proper approaches” to engage them during her pre-interview. At her post-interview, she elaborated that one of the approaches she would use was to “try to translate or get somebody that can translate for them.”

Michael (Section three) consistently stated during both of his interviews that he would use group work to bridge the gap between science and language. For example, during his pre-interview, he stated “I think just having kids that don’t speak English working with other kids or a student that can speak both languages.” The same sentiment was echoed during the post-interview when he stated “Hopefully, someone in the class speaks two languages and I can use them to translate and help kids who don’t speak English as well.”

On another note, Angel’s (Section two) belief that language would not affect her science teaching changed. Her response at the post-interview was as follows:

I would just [use] everything that I’m learning in my ESOL classes and just everything that I’ve learned form experience with helping my grandmother
understand something that I’m telling her. Just use pictures and ways of communicating with them. [If] I have a student in my class that only speaks this language and she’s learning English and I don’t want her to feel like we’re making her learn English…we can learn some things from her language.

Not only did Angel suggest strategies for helping ESOL students make connections, she talked about the need to validate students’ language backgrounds by having the class learn about students’ home language.

Eric (Section three) started off the semester with a ‘deficit’ view. His responses during the pre-interview focused on problems that ESOL students would have with the science curriculum. For example, he stated:

If we’re doing something in English, if we’re operating in the English language, and if the textbooks are in English…and a student can’t understand what I’m doing, I’m not going to say that it’s hopeless, but it’s going to be very turbulent trying to convey ideas across to those who can’t speak the English language.

Contrarily, during Eric’s post-interview, he articulated strategies that could be use to help ESOL students learn. He commented:

I would have to go and take the initiative to supply myself with bilingual dictionaries in the class. I know that they have Spanish/English dictionaries. I don’t know about Haitian/Creole…I just have to step up my level of proficiency of being able to attempt to try and establish some communication between me and my students. Also, if there’s an EOL specialist at the school, if they aren’t too busy of if they’re available, I could bring them in to the classroom and see if they could offer their assistance in translating or…establishing some communication between me and the student.

The consistency and changes in preservice teachers’ responses to the effect of students’ language backgrounds on their science teaching may be explained by the fact that the College of Education emphasizes the use of ESOL strategies. As one student stated, “ESOL strategies are drilled into our heads.”
Barriers to Multicultural Science Teaching

There are many obstacles that may limit students’ access to equitable learning opportunities. One of those obstacles is a teacher’s willingness to use students’ differences to enrich his or her academic curriculum. In this study, barriers to multicultural science teaching included 1) preservice teachers skimming the surface of the meaning of multicultural science teaching and/or equity in science teaching and 2) preservice teachers whose pedagogical approaches were limited (i.e. not taking into account students’ diverse backgrounds).

Surface Level Definitions. The excerpts below have been taken from preservice teachers whose definitions of multicultural or equitable science teaching remained at the surface level from pre- to post-interviews. That is to say they did not move beyond the “obvious” definitions (e.g. teaching to all backgrounds, incorporating cultures, treating all students the same).

• Sarah (Section one): I’d say [multicultural science teaching means] not teaching things that your stereotypical scientist has discovered but making sure to include female scientists and scientists of other races, from other countries…

The same description was given during Sarah’s post-interview:

Teaching science not only to all races, ethnicities, social classes, but teaching them about how their, I guess, how their culture is involved in science…

• Kim (Section two): [Multicultural science teaching] is teaching science that incorporates several cultures

There was no change between Kim’s pre and post-interview responses. In addition, when asked to explain what equity meant when teaching science during her pre-interview, Kim stated, “teaching everybody the same.” However, Kim was unable to explain what equitable science teaching meant during the post-interview.
Eric (Section three): [Multicultural science teaching] is the teaching of science for all ethnic groups. But, that still just encompasses just science teaching. There has to be some distinction…for some reason it seems like their ethnic background has to be taken into account as far as me teaching them science and I don’t…

Eric did not see a connection between science teaching and ethnic backgrounds. He viewed science as a universal concept, void of culture. During his post-interview, Eric stated:

Multicultural science teaching is geared towards instructing students from various cultures and backgrounds. I guess with the inclusion of their cultures. Again, I don’t know how science, with us being different human beings and all, and having physical differences, but I don’t know. Culture goes into ethics and stuff like that I don’t see how science and ethics, well [perhaps] science and ethics do encompass one another.

Throughout both interviews, Eric struggled with accommodating 1) the possibility of science having a culture and 2) the importance of using students’ cultural backgrounds in his science teaching.

Kathy (Section three): [Multicultural science teaching] means making it work for all students and what they get out of it.

When asked to elaborate on what making it work for all students would entail during the pre-interview, she was unable to provide an answer. During Kathy’s post-interview, she indicated that equity meant bringing in diversity. For Kathy, diversity meant bringing in different scientists. Kathy’s pre- and post-responses are consistent with the responses of other preservice teachers who skimmed the surface of what multicultural or equitable science teaching really means. The majority of preservice teachers who began with a surface level description of multicultural or equitable science teaching remained at that level. A possible explanation for these unchanging beliefs may be that instead of isolating diversity issues to specific days, these concepts must be explicitly addressed and emphasized to preservice elementary teachers throughout the semester.
**Limiting Pedagogy.** A limiting pedagogy was exhibited by those preservice teachers whose espoused instructional practices did not consider students’ diverse social class, language, and/or cultural backgrounds. Although the majority of preservice teachers interviewed exhibited culturally affirming pedagogical practices by the end of the semester, the pedagogical beliefs exhibited by a few preservice teachers may limit equitable opportunities for all students to learn quality science. Sample interview excerpts of changes or consistencies in pedagogical beliefs that ignore students’ differences are given in Table 12. The category “change” represents examples of pedagogical beliefs that changed from affirming students’ diverse backgrounds to ignoring students’ diverse backgrounds. The category “consistent” represents beliefs that did not change from the “limiting” pedagogical stance that was exhibited at the beginning of the semester.

Table 12.

Limiting Pedagogical Beliefs

<table>
<thead>
<tr>
<th>Pedagogical Beliefs</th>
<th>Pre</th>
<th>Post</th>
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<tr>
<td><strong>Change</strong></td>
<td>Maybe bringing in supplies and stuff. I would try and work around that because I know a lot of people who give free supplies.</td>
<td>Well, if they’re of a poor social class, obviously we can’t have all the material like the higher social class will be able to bring in. That can always limit lessons and activities. It will also limit home activities. If I send them [activities] home…social classes will definitely mess up what’s allowed.</td>
</tr>
<tr>
<td><strong>Consistent</strong></td>
<td>I don’t feel like [students’ differences] will [affect my science teaching].</td>
<td>Right now, I don’t feel like [students’ differences] does. I’m sure it does and I’m sure I’m going to learn more about that…</td>
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There was one preservice teacher who started off the semester taking students’ differences into consideration when teaching science. However, by the end of the semester, students’ differences were ignored. Instead, she focused on the disadvantages students from diverse cultural backgrounds experience and how those disadvantages may act as barriers to her science teaching. For example, when asked to explain how students’ social class and language backgrounds would affect her science teaching, Kim (Section two) makes the following comments at the beginning of the semester:

(Social class backgrounds) Maybe bringing in supplies and stuff…but I think I would try and work around that because I know a lot of people who give free supplies. (Language backgrounds) They may not be able to understand all the activities…I guess I would have to use my ESOL strategies, or ones I will learn.

However, by the end of the semester, the following comments were made Kim:

(Social class) Well, if they’re a poor social class, obviously we can’t have all the material…so that can limit lessons and activities. [And] if I send them different activities, social class will definitely mess up what allowed, like technology that is a huge one that will be affected. (Language backgrounds) It will affect if I’m teaching a lesson and they don’t recognize a word that’s common to them, or they can’t place it in like a meaningful sense…If you send [activities] home and there’s a language barrier, it may not come across as easy when their on their own or with their parents either

Furthermore, a few preservice teachers who possessed views that may limit students from reaching high academic standards were consistent in their responses from beginning to end. In other words, they resisted practices inclusive of all students. For example, at the beginning of the semester, Robin (Section three) stated that students’ social class backgrounds would not affect her science teaching. This view was also explicated at the end of the semester. Kathy (Section three) stated that the only effect that students’ language background would have on her science teaching was that “it may be hard to communicate ideas if they’re not English speakers.” However, she did not
suggest any strategies for modification. Similarly, during her post-interview, Kathy stated, “I don’t think they’ll understand me. I don’t think they’re going to learn very much.” Again, no suggestions for modifications were explicated. One possible explanation for these limiting pedagogical views may be the fact that these preservice teachers were not provided with an environment that consistently forced them to reevaluate their preexisting notions of equitable science teaching.

Summary

ANOVA results indicated that preservice elementary teachers’ Personal Science Teaching Efficacy (PSTE) scores and Science Teaching Outcome Expectancy (STOE) scores changed in a positive direction. However, results also showed a non-significant interaction effect between the pretest and posttest scores among course sections on both the PSTE and STOE construct. Therefore, there was not sufficient evidence to warrant the rejection of the claim that the PSTE or STOE mean scores among preservice elementary teachers enrolled in the community-based science methods course with an embedded service-learning component and those enrolled in the two university-based science methods courses were equal.

Observations and interviews suggest that by working directly with the children at the community center, preservice elementary teachers in the community-based science methods course modified their pedagogical practices to meet the needs of diverse student groups. In addition, preservice teachers expanded their description of effective science teachers to include characteristics such as caring and flexible attitudes.

The majority of preservice elementary teachers, across course sections, either already possessed or developed attitudes that were consistent with the call of reformation.
That is, they explicated equitable science teaching beliefs by taking into account students’ social class, language and cultural background when teaching science. Experiences which contributed to the development of these attitudes ranged from service-learning to collaborative group work. However, there were a few preservice teachers whose beliefs were resistant to change. In summary, preservice elementary teachers indicated that community-based service-learning positively influenced their self-efficacy and pedagogical beliefs about equitable science teaching and learning.
CHAPTER FIVE: DISCUSSION

Summary, Conclusion, and Implications for Science Education

This chapter begins with a review of the purpose and summary of the study. Following the summary, the conclusions and implications, for each research question, that arise from the research findings are discussed. Next, the limitations of the research findings are described. The chapter concludes with a discussion of recommendations for future practice and future research.

Summary of the Study

Professional Development Standard B (NRC, 1996) states that “learning experiences for teachers of science must occur in a variety of places where effective science teaching can be illustrated and modeled, permitting students to struggle with real situations and expand their knowledge and skills to appropriate contexts” (p. 62). On a similar note, Darling-Hammond (1996) and Calabrese Barton (2000) suggest that preservice teachers be provided with opportunities to interact with ethnically and culturally diverse students in authentic environmental settings. Research studies indicate that this authenticity helps preservice teachers develop positive beliefs and attitudes regarding diversity by creating a sense of comfort around ethnically and culturally diverse students (Wade, 1995; 2000).

Service-learning experiences provide preservice teachers with authentic environments which can be used to examine presuppositions, accommodate new beliefs,
link theory to practice, and refine pedagogical skills. Calabrese Barton (2000) states that service-learning experiences allow preservice teachers to “reflect on science, teaching, and students, separate from ‘schooling’ and therefore separate from their perceived expectations” (p. 825). Similarly, Wade (1995) asserts that service-learning experiences that are located in urban neighborhoods provide opportunities for preservice teachers to reflect critically on their personal beliefs and attitudes toward diversity, which increases their self-efficacy. Ukpokodu (2004) makes a poignant summarization of the value of field experiences such as service-learning by stating, “Preservice teachers can read all the books about diversity, engage in simulations, but unless they have opportunities to interact with culturally different individuals [students] in authentic settings, they will not gain the critical knowledge, skills and dispositions needed to successfully work with them” (p. 27). The results of the present study support the value of preservice teachers engaging in service-learning experiences.

The primary purpose of this study was to explore the effects of community-based service learning on preservice elementary teachers’ self-efficacy beliefs about equitable science teaching and learning. More specifically, this study addressed the following research questions:

RQ1. In what ways, if any, are the perceptions of preservice elementary teachers enrolled in a community-based science methods course with an embedded service-learning component different from those enrolled in two university-based science methods courses without a service-learning component with respect to their ideas concerning the characteristics of effective science teachers?
RQ2. What is the difference in the Personal Science Teaching Efficacy (PSTE) scores, and Science Teaching Outcome Expectancy (STOE) scores, among preservice elementary teachers enrolled in a community-based science methods course with an embedded service-learning component and those enrolled in two university-based science methods courses without an embedded service-learning component?

RQ3. What science methods course experiences, if any, are identified by preservice elementary teachers as having a positive effect on their science teaching efficacy beliefs concerning equitable science teaching?

RQ4. How do preservice elementary teachers’ beliefs about multicultural science teaching change, if at all, over the course of a semester?

This study utilized a mixed-methods research design to answer the aforementioned research questions. Data were collected from 67 preservice teachers registered in three elementary science methods courses. One of the courses was housed at an urban neighborhood community center and had an embedded service-learning component (Section one). The other two courses were housed at the main campus of the university (Sections two and three). Sections one and two were taught by Instructor Roberts. Section three was taught by Instructor Edwards.

Semi-structured interviews and questionnaires, given at the beginning and end of the semester, were used to examine preservice elementary teachers’ beliefs and attitudes about teaching science to diverse populations. Using constant comparative analysis, data were analyzed for patterns and themes. Inductive analysis was used to allow patterns and themes to emerge from the data (Patton, 1990, p. 390). A quasi-experimental design was
used to measure changes in science teacher efficacy beliefs in regard to equitable science teaching and learning through the Self-Efficacy Belief about Equitable Science Teaching and Learning (SEBEST) instrument (Ritter et al., 2001). This instrument was also given at the beginning of the semester, as a pretest, and at the end of the semester, as a posttest. Changes in preservice teachers’ self-efficacy beliefs were analyzed using two 3 x 2 Factorial Repeated-Measures ANOVAs.

Preservice teachers’ self-efficacy beliefs about equitable science teaching may be dependent on many factors. For example, since many teachers aspire to be effective science teachers of all students, and efficacy beliefs affect teachers’ efforts, aspirations, and the goals they set (Bandura, 1997), the characteristics ascribed to effective science teachers may underpin teachers’ confidence in their ability to meet this goal. Knowing the characteristics preservice elementary teachers ascribe to effective science teachers is important in order to identify and provide teacher education experiences that challenge preservice teachers to critically reflect on the appropriateness of those beliefs in an authentic environment. Previous research on the characteristics of effective teachers of diverse students indicates that these teachers possess empathetic attitudes, are flexible, and use diverse and didactic instructional approaches which take into account students’ sociocultural differences (Atwater, 2000; Gay, 2000; Ladson-Billings, 1994). This research study sought to add to the existing body of literature in this area by 1) identifying preservice elementary teachers’ perceptions of effective science teachers before entering their science methods course and 2) investigating the effect of educational experiences, particularly community-based service-learning, on preservice elementary teachers’ beliefs about effective science teachers.
Additionally, Bandura (1997) states that there are four sources which affect an individual’s self-efficacy. *Mastery experiences* are considered to be the most powerful in affecting teachers’ self-efficacy. Previous research studies confirm the positive effects that field experiences, such as tutoring or student teaching, have on preservice teachers’ efficacy beliefs (Enochs & Riggs, 1990; Weaver et al., 1979; Woolfolk Hoy & Burke Spero, 2005). However, none of the aforementioned research studies have investigated the effect of field experiences, such as community-based service-learning, on preservice elementary teachers’ science teaching efficacy beliefs. Equally important is the fact that no research study has explored the effect of community-based service-learning on preservice elementary teachers’ self-efficacy beliefs about equitable science teaching. Therefore, this research sought to add to the existing body of knowledge about the effects of field experiences, such as community-based service-learning, on preservice elementary teachers’ self-efficacy beliefs regarding equitable science teaching and learning. In addition, this research sought to identify specific course experiences that either positively or negatively affect preservice teachers’ self-efficacy beliefs about teaching science to diverse populations.

Self-efficacy beliefs about equitable science teaching may also be influenced by preservice teachers’ beliefs about multicultural science teaching. If preservice teachers do not recognize the importance of using multicultural practices that meet the needs of all students, they will continue to implement ineffective instructional practices. Ineffective instructional practices contribute to the lack of academic success experienced by many ethnically and culturally diverse and low-income students (Atwater, 2000). The lack of success experienced by students may in turn affect a teacher’s confidence in his or her
ability to affect the change that is needed in order to have all students become scientifically literate.

Previous research studies have been conducted on the effects of service-learning on preservice teachers’ beliefs about multicultural teaching (Wade, 1995, Wade, 2000). Within science education, few studies have examined the effects of community-based service-learning on preservice teachers’ beliefs about multicultural science teaching (Calabrese Barton, 2000). The research related to effects of service-learning on beliefs about multicultural science teaching was limited to preservice secondary science teachers. Calabrese Barton (2000) highlighted the importance of using service-learning experiences to help preservice teachers develop multicultural science teaching practices. This study sought to add to existing knowledge base in this area by researching the effect of community-based service-learning on preservice elementary teachers’ beliefs about multicultural science teaching. In conclusion, this study endeavored to contribute to the existing knowledge base of the effects of field experiences (mastery experiences) such as service learning on preservice teachers’ self-efficacy beliefs and pedagogical beliefs.

Conclusion and Implications

Research Question 1: Perceived Characteristics of Effective Science Teachers

Effective Science Teacher Conclusion

The data for this research question was generated through qualitative analyses of preservice elementary teachers’ pre and post-responses to the following question: What are the characteristics of an effective science teacher? Using constant comparative analysis, responses were categorized into two emergent themes, teacher pedagogy and creating a learning community. The descriptive data presented in Table 6 (page 132)
suggests that by the end of the semester there were differences in the characteristics attributed to effective science teachers across course sections.

In relation to the theme teacher pedagogy, preservice teachers in Section one stated that in addition to content knowledge and diverse instructional approaches, characteristics which were also explicated during pre-interviews, effective science teachers are flexible. As a matter of fact, flexibility was the most prevalent characteristic stated by preservice teachers in section one. In Section two, preservice teachers thought that in addition to being engaging, a characteristic which was also indicated during pre-interviews, effective science teachers possessed content knowledge and were prepared. For preservice teachers in Section three, the ability of effective science teachers to engage students was the characteristic that emerged during the pre-interview and post-interview.

In relation to the theme creating a learning community, preservice teachers in Section one believed that effective science teachers were caring and patient. In Section two, preservice teachers also felt that effective science teachers were caring. These two characteristics, being caring and being patient, were not mentioned during pre-interviews. Additionally, as opposed to the characteristics exhibited by Mr. Smith, the teacher in Gilbert and Yerrick’s study (2001), preservice teachers in Sections two and three explicated the importance of allowing students to understand science by doing science.

These differences and similarities across course sections may be explained by looking at the course context and/or course instruction. For example, the experiential learning opportunity (i.e. service-learning) that was given to preservice teachers in Section one allowed them to understand that one size really doesn’t fit all (Calabrese Barton, 2000). That is, what works for one student may not work for all students.
Cognizant of this fact, along with being flexible, preservice teachers simultaneously began to develop patient attitudes. In addition, preservice teachers in Section one realized, through experience, that it was very important for science teachers to be able to modify their lessons in order to accommodate unforeseen circumstances and the needs of their students (i.e. time constraints, student diversity). Furthermore, because preservice teachers were afforded opportunity to establish teacher-student relationships, they began to develop empathetic attitudes. Similar results were found by Wade (1995) in her study of the effects of service-learning on self-efficacy. Based on her findings, Wade concluded that the development of empathetic attitudes was a direct result of preservice teachers’ service-learning experiences. However, preservice teachers in Section two also explicated the importance of effective science teachers having caring attitudes. This may be an outcome of Instructor Roberts’ explicit discussions of the inequities experienced by students from diverse ethnic and low-income backgrounds (Rodriguez, 1998a). Because preservice teachers entered their teaching education courses believing that America is a meritocracy (Rodriguez, 1998b), the explicit discussions on diversity helped to deconstruct these previously held beliefs while concomitantly helping preservice teachers develop empathetic attitudes. It may also be a result of the caring attitude modeled by Instructor Roberts which was demonstrated when she allowed students’ voices to be heard and modified her curriculum to meet the needs of the preservice teachers.

Modeling (i.e. *vicarious experiences*), if presented appropriately, positively affects preservice teachers’ beliefs (Bandura, 1997).

During course discussions, instructor Roberts emphasized the need for preservice teachers to be knowledgeable of content before planning a lesson. For that reason, it is
expected that both sections one and two would indicate that content knowledge was an important characteristic of effective science teachers. Instructor Roberts also emphasized the need for preservice teachers to be prepared before implementing an activity. However, this characteristic, along with being engaging, may have been more prevalent in Section two due to the fact that preservice teachers were required to create and implement mini-lessons using their peers as the learning community. Because feedback was given at the end of the lesson, preservice teacher may have felt the need to be more engaging and better prepared as to avoid feelings of inadequacy (Bandura, 1997).

Instructor Edwards emphasized the need for preservice teachers to engage children’s attention by allowing them to explore and formulate questions and answers. This emphasis underscored preservice teachers’ previously held beliefs that effective science teachers should be engaging (Pajares, 1992). Therefore, it may be expected that preservice teachers in Section three ascribed the ability to engage students by using hands-on activities as effective characteristics of effective science teachers. Findings from this study lead to the conclusion that although many preservice teachers, across course sections, possessed beliefs of teacher effectiveness that may serve as building blocks to students’ academic success, the preservice teachers in Section one explicated more characteristics of effective science teachers that were complimentary to the existing literature base on effective teachers of diverse populations (Atwater, 2000; Gay, 2000; Ladson-Billings, 1994; Zeichner, 1993). These results are consistent with previous conclusions on the effectiveness of service-learning (Wade, 1995).
Effective Science Teacher Implications

The confidence a teacher has in his or her ability to be an effective science teacher may be undergirded by beliefs about teacher effectiveness. The finding that preservice teachers involved in community-based service-learning explicated more characteristics of teacher effectiveness that are consistent with previous research on the characteristics of effective science teachers of diverse populations (Atwater, 2000; Gay, 2000) provides vital information to the science education community. The service-learning experience may have challenged preservice teachers’ preconceived beliefs of teacher effectiveness. Therefore, preservice teachers were required to accommodate new beliefs of teacher effectiveness. This accommodation led to preservice teachers expanding their beliefs about the characteristics effective teachers should possess. These expanded views of teacher effectiveness are requisite if teachers are to be successful in providing equitable opportunities for all students to learn quality science.

In science education, Atwater (2000) has delineated a picture in which students of color have been prevented from achieving academic excellence due to the obstinate barriers that remain in place. One of the barriers includes the ineffective instructional practices that have been exhibited by teachers who are in charge of educating today’s diverse youth. Atwater (2000) posits that effective science teachers of diverse student groups are multicultural science teachers. Not only do they possess content knowledge, they care enough to adapt the science curriculum to meet the diverse needs of their students. Furthermore, they acknowledge, respect, and use students’ differences to enrich their science curriculum. Irvine (2003) would contend that these teachers “see with a cultural eye.” Since many teachers aspire to be effective teachers of all students, service-
learning may be an effective tool in developing preservice teachers’ abilities to see with a “cultural eye.”

*Research Question 2: Self-Efficacy about Equitable Science Teaching*

*Self-Efficacy Beliefs about Equitable Science Teaching Conclusion*

The data for this research question were gathered through utilizing the Self-Efficacy Beliefs about Equitable Science Teaching and Learning (SEBEST) instrument. This instrument was given at the beginning of the semester, as a pretest, and at the end of the semester, as a posttest. Data were analyzed through two 3 x 2 Repeated-Measures Factorial ANOVA tests. Tests were independently conducted on the Personal Science Teaching Efficacy (PSTE) and Science Teaching Outcome Expectancy (STOE) constructs. The factorial ANOVA results are presented in Tables 7 and 9 (pages 144 and 146).

The results of the analyses indicated that preservice elementary teachers’ PSTE and STOE mean scores changed in a positive direction. Preservice teachers improved their scores from pretest to posttest. These results support earlier research findings that have also noted positive changes in preservice teachers’ PSTE and STOE mean scores (Enochs & Riggs, 1990; Morrell & Carroll, 2003). However, since the interaction effects were not significant, results of the analyses also indicated that there were no statistically significant differences in the PSTE or STOE scores among preservice teachers in Sections one, two, and three. In addition, ANOVA results showed that the interaction effect sizes for PSTE and STOE, 0.001 and 0.009 respectively, were small.

The results on the STOE construct were expected. Enochs and Riggs (1990) and Tschannen-Moran et al. (1998) have acknowledged that outcome expectancy is a difficult
construct to measure due its connectedness with a myriad of variables. Since a
discussion of STOE results will not add to the existing body of knowledge in this area,
they will not be discussed in this section. However, the non-significant interaction and
small interaction effect size for the PSTE construct, 0.001, might suggest that the test did
not have enough power to find a difference if one truly existed. Therefore, no
conclusions can be reached about the relationship between community-based service-
learning and PSTE scores in the population. This does not mean that community-based
service-learning does not moderate preservice elementary teachers’ Personal Science
Teaching Efficacy, but that this study, as conducted, did not have enough power to rule
out chance as the cause of the differences. A larger sample size may have led to different
results. However, there is also the possibility that a significant difference was not noted
because no real differences exist in the population.

Research findings on the effects of field experiences on teaching efficacy vary.
For example, many quantitative studies have found very little to no correlation between
field experiences and science teaching efficacy (Morrell & Carroll, 2003; Plourde, 2002;
Weaver et al., 1979). As a matter of fact, Plourde (2002) found that student teaching
decreased preservice teachers’ Science Teaching Outcome Expectancy beliefs.
Contrarily, Woolfolk Hoy and Burke Spero (2005) found that teacher efficacy increased
during teacher preparation and student teaching. In addition, when qualitative findings
were combined with quantitative findings, Weaver et al. (1979) concluded that field
experiences did have a significant positive effect on preservice teachers’ science teaching
efficacy beliefs. The ANOVA results of this study confirm previous quantitative
research studies that found very little correlation between field experiences and science
teaching efficacy. However, qualitative results from the post-questionnaire, discussed below (page 198), support the positive effects of community-based service learning on preservice elementary teachers’ self-efficacy beliefs about equitable science teaching and learning.

*Self-Efficacy Beliefs about Equitable Science Teaching Implications*

No other study has investigated the effects of community-based service-learning on preservice elementary teachers’ self-efficacy beliefs about equitable science teaching and learning. Due to a non-significant interaction effect and small interaction effect size, the inferential statistics from this study do not allow any conclusions to be made about the effect of community-based service-learning on preservice elementary teachers’ science teaching efficacy about equitable science teaching and learning. As stated above, this does not mean that a relationship does not exist between community-based service-learning and preservice elementary teachers’ self-efficacy beliefs about equitable science teaching. In any case, the positive changes that occurred from pretest to posttest should not be ignored.

Personal efficacy beliefs have been defined as an individual’s perception of his or her abilities to execute the required actions needed to deal with stressful, unpredictable and ambiguous situations (Bandura, 1997). Moreover, personal efficacy beliefs may influence an individual’s intentional acts or agency. In the context of teaching, a teacher’s agency is his or her ability to decide what is, or is not, implemented in their classroom. Bandura (1997) contends that self-reflection is vital to the development of human agency. In other words, changes in self-efficacy are dependent upon a person’s ability to reflect on his or her actions.
Providing an environment that encourages reflection helps preservice teachers untangle the web of deeply entrenched personal beliefs they possess about teaching and learning. Van Manen (1977, as cited in Yost et. al, 2000) divided reflection into three stages. The first stage encompassed the effective application of skills and technical knowledge in the classroom. The second stage required individuals to reflect upon the assumptions underpinning pedagogical practices and the consequences of those assumptions on student learning. The last stage fostered students’ ability to question the moral and ethical aspects of decisions related to the classroom. It was during this stage that teachers were able to make connections between theory and practice and the sociocultural forces that influence them (i.e. critical reflection).

Critical reflection in the service-learning context connects students’ community experiences to academic learning (Eyler & Giles, 1999). Wade (1995, 2000) and Calabrese Barton (2000) underscore this point by stating that guided reflections are a power factor in preservice teachers’ professional development. If all students are to be provided with equitable opportunities to become scientifically literate, teacher education programs must challenge preservice teachers to make sense of non-sensible situations, identify areas of need, define goals of improvement, and embrace alternative pedagogical practices that include using the diverse ways of knowing and learning students bring to the science classroom. If not, preservice elementary teachers will continue to enter their professional careers lacking confidence in their ability to teach science to diverse populations.
Research Question 3: Sources of Self-Efficacy

Sources of Self-Efficacy Conclusions

The data for this question were gathered from the post-questionnaires that were distributed at the end of the semester. Preservice teachers were asked to evaluate the effect of eight course experiences on their ability to effectively teach science to diverse populations. Ratings ranged from a negative effect (1) to a positive effect (5) for each experience. Descriptive statistics are presented in Table 10 (page 148). Open ended questions were also asked, coded, and categorized to gain further insight into science methods course experiences that either positively or negative affected preservice teachers beliefs in their ability to be effective science teachers of diverse students.

Bandura (1997) posits that there are four sources from which individuals either gain or lose confidence. These four sources include mastery experiences, vicarious experiences, emotional and physiological cues, and verbal persuasion. Mastery experiences are considered to be the most powerful in affecting teaching efficacy (Bandura, 1997). The importance of mastery experiences was underscored by preservice teachers in Section one who rated service-learning as having the most positive effect on their self-efficacy beliefs about teaching science to diverse population. Analyses of preservice teachers’ open-ended responses support the aforementioned finding. Preservice teachers commented that working with the kids provided eye opening experiences that made them reevaluate previous held beliefs about diversity and their ability to teach science to diverse students. However, there were a couple of students who commented that the behavioral problems they experienced at the community center had a negative affect on their ability to teach science effectively to diverse students.
Preservice teachers in Sections two and three rated verbal persuasion (Bandura, 1997) as having the most positive effect on their self-efficacy beliefs; that is the constructive criticism or feedback received from the science methods course instructor and/or their peers. Preservice teachers’ open-ended responses support this finding. For instance, preservice teachers in Section two explicated that along with the diversity assignments and discussions that challenged them to reflect critically on their lives and the lives of others, instructor and peer feedback helped them to prepare for the diversity they will encounter in the classroom. Preservice teachers in Section three underscored the importance of peer feedback, while working in collaborative groups, and its positive effects on their ability to teach science to diverse students. It was expected that preservice teachers in Section two would not rate field experiences as having the most positive effect on their confidence in regard to teaching diverse populations since they did not participate in any field experiences. It is also worth noting that even though field experiences (i.e. field observations and student interviews) were used in Instructor Edwards course, Section three, these experiences did not have as strong of a positive effect as community-based service learning. These findings, coupled with the fact that preservice teachers involved in community-based service learning showed positive gains in Personal Science Teaching Efficacy (PSTE), lead to the conclusion that when field experiences are used as mastery experiences, they positively influenced preservice teachers’ self-efficacy beliefs about equitable science teaching.

Sources of Efficacy Implications

For those preservice teachers who participated in community-based service learning, the course experience that was rated as having the most positive effect on their
confidence was field experience. Analyses of open-ended responses highlight the importance of the service-learning experience and its positive effect on their confidence in regard to teaching science effectively to diverse students. However, Wade (1995) cautions teacher educators that service-learning may reinforce preservice teachers’ negative beliefs and attitudes toward teaching diverse students. This is especially true if learning experiences are not carefully planned. Even with Instructor Roberts’ thoughtful planning, this proved to be the case for a couple of preservice teachers in Section one. However, for the most part, preservice teachers indicated that service-learning was a valuable experience that allowed them to reflect on what it really meant to be an effective science teacher. These sentiments are validated by the characteristics preservice teachers attributed to effective science teachers in research question one.

Previous research studies have documented the positive effect of mastery experiences such as field experiences (e.g. tutoring and student teaching) on preservice teachers’ teaching efficacy beliefs (Enochs & Riggs, 1990; Weaver et al., 1979; Woolfolk Hoy & Burke Spero, 2005). However, these studies did not take into account the differences between the sociocultural backgrounds of teachers and students that may affect preservice teachers’ self-efficacy as it relates to teaching science to diverse populations. The following study adds to the existing knowledge base in this area by delineating the powerful effects of mastery experiences such as community-based service-learning on preservice elementary teachers’ self-beliefs about equitable science teaching and learning.
Multicultural Science Teaching Conclusions

Qualitative analyses of students’ responses to interview questions (see Appendix B) were used to gather data for this research question. Responses were categorized into two emergent themes: building blocks to multicultural science teaching and barriers to multicultural science teaching. Building blocks to multicultural science teaching included preservice teachers’ transformative definitions of multicultural or equitable science teaching and preservice teachers’ abilities to adjust their pedagogical approaches, taking into account differences in students’ social class, language, or cultural backgrounds (multicultural pedagogy). Barriers to multicultural science teaching included teachers’ surface level definitions of multicultural or equitable science teaching and pedagogical practices that did not take into account differences in students’ social class, language, or cultural backgrounds (limiting pedagogy). Descriptive data is presented in Tables 11 and 12 (pages 170 and 178).

Analyses indicated that by the end of the semester, many preservice teachers possessed culturally affirming beliefs toward multicultural science teaching. Yerrick and Hoving (2003) would refer to these teachers as producers. Preservice teachers acknowledged in their responses the need to consider students’ sociocultural backgrounds when designing their instructional approaches. For example, when asked how students’ social class backgrounds would affect her science teaching, a preservice teacher stated that she would be more inclined to give them the opportunity to learn something new. In addition, she stated that she would not put students in the position of buying supplies if they couldn’t afford it. Instead, she would purchase the material for them. These
responses diverged from the limited pedagogical beliefs she elucidated during the pre-interview. The abovementioned statement exemplifies comments made by several preservice teachers about the effects of students’ sociocultural backgrounds on their science teaching.

When compared to the other course sections, findings also indicated that by the end of the semester, preservice teachers who participated in community-based service learning articulated descriptions of equity in science teaching were more congruent with its true definition; that is treating students fairly by taking into account differences (Atwater, 1993, 1996, 2000; Banks, 1996, 2002; Lee & Lukyx (forthcoming)). Villegas & Lucas (2002) would contend that these preservice teachers are more likely to “use his or her knowledge about students’ lives to design instruction that build on what they already know while stretching them beyond the familiar” (p. 21). These findings are underscored by previous research which investigated the effects of service-learning on preservice teachers’ beliefs about multicultural science teaching. Calabrese Barton (2000) also found that community-based service-learning helped preservice teachers to question their own beliefs regarding the interconnectedness of students’ backgrounds and teacher pedagogy. As a result, preservice teachers began to articulate and implement equitable pedagogical practices that were inclusive of students’ diverse backgrounds. Equally important is the finding that for some preservice teachers, the need to incorporate students’ diverse ways of knowing and learning into their pedagogical practices was limited to one particular diverse student group, ESOL students. This was especially evident in the pedagogical beliefs of the preservice teachers in sections two and three.
Conversely, a few preservice teachers remained at the surface level with their descriptions of multicultural science teaching and/or equity in science teaching. For example, they would simply describe multicultural science teaching as teaching science to all students or incorporating students’ cultures into science with displays of diverse scientists. Similarly, when asked how students’ sociocultural backgrounds would affect their science teaching, some preservice teachers responded that it would not. Yerrick and Hoving (2003) would refer to these preservice teachers as *reproducers* because they will most likely reproduce their past educational experiences with their future students. These results are consistent with previous studies that indicate the resistance of preservice teachers to ideological and pedagogical changes inclusive of multiculturalism (Cochran-Smith, 1991; McIntosh, 1993; Rodriguez, 1997, 1998; Yerrick & Hoving, 2003). These findings support the argument that teachers continue to respond in ways that address the complexities of teaching and learning in a multicultural society (Atwater, 2000; Grant & Tate, 1995). Teachers who do not explore the world explore the world of *all* their students send the tacit massage that *all* students do not have the same worth or value. Furthermore, when science teachers fail to appropriately respond to issues of diversity within their curriculum and teaching practices, they choose to provide inequitable access to opportunities for scientific literacy. Findings from this study, combined with the findings from previous research lead to the conclusion that community-based service-learning is an effective tool for crafting preservice elementary teachers’ beliefs about multicultural science teaching (Calabrese Barton, 2000).
Preparing teachers for a multicultural society is very important for the success of reform initiatives. However, preservice teachers’ lack of meaningful and authentic experiences with diverse students in their teacher education programs, coupled with the fact that preservice teachers have little to no cross-cultural knowledge due to their limited exposure to diversity (Banks, 2002; Ladson-Billings, 1994), may serve as a barrier to preservice teachers’ development of multicultural knowledge. One important finding to emerge from this study is the fact that preservice teachers must be provided with authentic experiences that allow them to work with culturally diverse students over time (Calabrese Barton, 2000; Wade, 2000). In addition, not only must science teacher educators have explicit discussions regarding the inequities that exist within science education, preservice teachers must be forced to critically examine their beliefs before, during and after these discussions.

Another important finding that emerged from this study was the fact that for many preservice teachers, the term “race/ethnicity” was synonymous with language and/or culture. Moreover, as explicated by a few preservice teachers during discussions of diversity, a person’s race does not matter because everyone should be treated the same in America. An individual’s race is important for discussion because it is intertwined with their beliefs, attitudes, and behaviors (West, 1993). It is a characteristic that is used by some preservice teachers to pre-judge students’ intelligence and capabilities (Atwater, 2000). Recognizing the interconnectedness of race, beliefs, and attitudes is an important first step for developing multicultural science teachers. Therefore, an implication of this study is the need for science teacher education programs to assist in the development of
“sociocultural consciousness” (Villegas & Lucas, 2002), by interweaving explicit discussions on the interconnectedness of race and science throughout preservice teachers’ science curriculum and field experiences.

The sociocultural differences that exist between teachers, students, and the science curriculum serve to further disengage and marginalize diverse student groups. Teachers must acknowledge the differences that abound within others. That includes acknowledging the fact that race/ethnicity influences an individual’s way of thinking and behaving (Banks, 2002; Villegas & Lucas, 2002; West, 1993). This is critical for the academic success of diverse student populations. Many multicultural theorists and practitioners contend that teachers need to know the meaning of culture, how culture impacts learning and schooling, the ways in which schools and classrooms function as a culture, and the nature of ethnic, racial, and cultures different from their own (Atwater, 1994; Atwater & Crockett, 2003; Villegas & Lucas, 2002). Without this knowledge, Villegas and Lucas (2002) state that teachers will be unable to cross the sociocultural borders that divide so many of them from their students.

In spite of preservice teachers’ lack of sociocultural consciousness as it relates to the interconnectedness of race and science teaching, many preservice teachers displayed beliefs and attitudes consistent with reform recommendations. They became more aware of the need to make their pedagogical practices more inclusive of diverse students’ backgrounds. This was especially evident in those preservice teachers in the community-based science methods course. Because preservice teachers’ receptiveness of multicultural science teaching or diversity issues may be limited by their lack of cross-cultural knowledge and/or experiences (Boyle-Baise, 2000; Ladson-Billings, 1995), the
The inclusion of direct meaningful interaction within the service-learning context allowed preservice teachers sufficient exposure to diverse student groups. This exposure appears to have increased their understanding of cultural differences and the need to be equitable by using these differences to enrich their instructional practices. These results confirm earlier research on the effects of service-learning on preservice teachers’ beliefs about multicultural science teaching (Calabrese Barton, 2000). However, Calabrese Barton’s study was limited to the beliefs of preservice secondary science teachers. For this reason, this study contributes to the existing knowledge base by focusing on the effects of service-learning on preservice elementary teachers’ beliefs regarding multicultural science teaching.

Findings also indicated that the majority of preservice teachers in Sections two and three explicated more strategies to use with students from different language backgrounds (i.e. ESOL students). They indicated that they believed that as opposed to other sociocultural groups, teaching science to ESOL students, because of the language barrier, would pose more of a challenge. Therefore, it was important to use multicultural teaching practices with ESOL students in order to provide relevant connections between the curriculum and their language backgrounds. A plausible explanation for this would be the fact that, as one student put it, “ESOL modifications are drilled into our heads”. The College of Education explicitly endorses the importance of making modifications to meet the needs of ESOL students. The fact that preservice elementary teachers are required to take at least three ESOL courses underscores its importance. Therefore, it should be expected that preservice teachers expressed the belief that science teachers should modify their curriculum to meet the needs of ESOL students.
Preservice teachers are required to take one course, *Teaching Diverse Populations*, which deals with how to effectively teach diverse student groups. However, after taking this one course, preservice teachers compartmentalize this information as something that is not need to teach science effectively. Given the limited nature of preservice teachers’ experiences with diversity, the College of Education must do more than offer one course aimed at teaching *all* children effectively. Teacher educators must do more than offer specific strategies within their own courses that are geared towards ESOL students. Colleges and teacher educators must explicitly acknowledge, and embed within their curriculum, the need for effective teachers of *all* diverse student groups to be flexible and diverse in accommodating the needs of their students.

These abovementioned findings are important to the science education community because reform initiatives state that all students deserve equitable opportunities to become scientifically literate, regardless of their background. Atwater (1996) contends that in order for *all* students to become scientifically literate, science teacher education programs should focus on cultivating multicultural science teachers. In other words, science teacher education programs must foster the development of teachers who strive for equity in science teaching. Furthermore, if reform efforts are serious in their quest to meet the needs of a multicultural society, science teacher education programs must infuse multicultural education, both explicitly and implicitly, throughout the science education curriculum. Preservice teachers must be presented with experiences that challenge them to reflect on their preconceived beliefs regarding diversity which may undermine the goal of providing equitable educational opportunities for *all* students. Findings from this study suggest that community-based service-learning...
is a powerful pedagogical tool that challenges the hegemonic views possessed by preservice teachers regarding issues of diversity and science teaching. Moreover, it facilitates the production of multicultural science teachers.

Limitations of Study

1. Internal validity is defined as the “approximate validity with which we infer that a relationship between two variables is causal” (Cook and Campbell, 1979, p. 37). Internal validity is important when making claims of causality. The study’s sample size may have decreased the study’s power. In addition, due to the fact that the same instrument was used for the pretest and posttest, there is a threat to internal validity due to response shift bias. However, the 3 x 2 Factorial Repeated-Measures ANOVA design may have controlled for the main effects of history, maturation, testing, statistical regression, and instrumentation. Further threats to internal validity were limited through the addition of qualitative data in the form of semi-structured interviews, observations, and questionnaires.

2. External validity is the degree to which study results can be generalized to and across populations of settings, persons, or times. The researcher was concerned with two forms of external validity, population validity and ecological validity. Population validity is the ability to generalize results obtained from a sample to a larger population. Since random sampling was not possible because preservice teachers self-registered for their science methods course, the study’s population validity is limited. Ecological validity refers to the degree to which study results can be generalized across settings. The researcher attempted to minimize threats to ecological validity by providing an explicit description of the experimental
treatment. In summary, because of the threats to external validity, caution must be used when generalizing the results of this study to other populations.

3. The qualitative results of the study are limited by the use of interviews and the small sample drawn from the population. However, in qualitative research, no true generalizations are possible because all observations are defined by the study’s context and researcher’s subjective interpretations.

In summary, caution must be used when generalizing the results of this study to other populations. The obligation for determining whether or not findings from this study may be transferable belongs to the reader.

Recommendations for Practice

Teachers must not merely take courses that tell them how to treat their students as multicultural clients, in other words, those that tell them how to identify differences in interactional or communicative strategies and remediate appropriately. They must learn about the brilliance the students bring with them...Until they appreciate the wonders of cultures represented before them—and they cannot do that without extensive study most appropriately begun in college-level courses—they cannot appreciate the potential of those who sit before them, nor can they begin to link their students’ histories and words to the subject matter they present in the classroom (Delpit, 1995, p. 182).

Tschannen-Moran et al. (1998) proposed a teacher efficacy model which encompasses a five-step circular process through which beliefs are created, evaluated, utilized and then lead to new sources of efficacy information (see Figure 5, p. 67). The sources of efficacy delineated in this model are those explicitly postulated by Bandura (1977): mastery experiences, vicarious experiences, verbal persuasion, and physiological arousal. Besides those proposed by Bandura, this model does not include other sources of efficacy that may affect teacher efficacy beliefs. If this model is to be applicable to teachers’ self-efficacy beliefs in regard to teaching science to diverse populations, the
researcher suggests that this model also include teachers’ beliefs about effective science
teachers and multicultural science teaching.

Given the strong relationship that exists between teacher efficacy and student
achievement (Tschannen-Moran, Woolfolk Hoy, & Hoy, 1998), there is a need to
determine what teacher education practices will develop teachers who are confident in
their ability to provide equitable learning opportunities to all students. Highly efficacious
teachers are more open to new ideas (Bandura, 1997; Woolfolk & Hoy, 1990).
Furthermore, they are willing to implement diverse pedagogical practices to better meet the needs of their students (Bandura, 1997; Atwater, 2000). This study has sought to contribute to the existing knowledge base by presenting the science education community with practices that facilitate the development of efficacious science teachers of all students (i.e. those teachers who are confident in their ability to affect change in student achievement regardless of students’ sociocultural backgrounds). These teachers are also referred to as multicultural science teachers (Atwater, 2000; Barton, 2000). The results of this study, coupled with the understandings provided in existing research, lead to some recommendations for science teachers and science teacher educators.

Whether called by one name or many names, efficacious teachers are needed to make science for all an attainable goal. Bandura (1997) states that individuals who possess a strong sense of self-efficacy persist in the face of failure. Atwater (2000) argues that efficacious teachers modify their pedagogical practices to acknowledge students’ differences and use these differences as strengths, instead of weaknesses. They set high expectations for student success. Moreover, efficacious science teachers of all students are caring teachers who form strong teacher-student relationships in order to
create a learning community. These caring relationships undergird teachers’ commitments to providing equitable learning opportunities for all students.

Results of this study indicate that community-based service-learning may be used as a pedagogical tool to affirm, challenge and expand preservice teachers’ descriptions of effectiveness. This is important because the characteristics that preservice teachers attribute to effective science teachers may affect their confidence in their perceived ability to be effective science teachers of diverse students. Based on the findings in this study, it is recommended that science teacher educators identify preservice teachers’ beliefs about the characteristics of effective science teachers at the beginning and end of the semester. This identification process will allow teacher education programs to determine if they are producing teachers who are equipped and confident in their ability to be effective science teachers of all students. In addition, since the community-based service-learning experiences expanded preservice teachers’ descriptions of effective science teachers, it is also recommended that science teacher education programs take an extensive look at the feasibility of embedding service-learning experiences in science methods courses.

Community-based service-learning experiences in urban neighborhood communities allow preservice teachers to see relevance in what they are learning. In addition, it provides preservice teachers with opportunities to appreciate the cultural capital (i.e. diverse ways of knowing and learning) of diverse student groups (Delpit, 1995). Findings from this study, along with others (Barton, 2000; Wade, 1995, 2000), illuminate the positive effects service-learning has on preservice teachers’ self-efficacy beliefs and pedagogical beliefs regarding equity and science teaching. Czerniak and
Chiarelott (1990) emphasize the importance of finding strategies to reduce preservice teachers’ science anxiety if the goal of science education is really that of providing all students with opportunities to become scientifically literate. Many preservice teachers expressed the sentiment that the community-based service-learning experience challenged them to reflect on their preconceived beliefs about science teaching and diversity. Therefore, it is recommended that teacher educators embed critical reflection within service-learning experiences. This may be accomplished by using Rodriguez’s (1998b) sociotransformative constructivist (STC) orientation.

Rodriguez (1998b) posits that STC is a strategy for counterresistance (i.e. resistance to ideological and/or pedagogical change) that “has potential for helping preservice teachers learn to teach science for diversity and understanding” (p. 617). In addition, results indicate that STC shows promise in aiding preservice teachers to critically examine their presuppositions about what constitutes being an effective science teacher. STC makes use of cognitive constructivist orientations and sociocultural constructivist orientations. These orientations underpin the four closely connected components of STC: dialogic conversation, authentic activity, metacognition, and reflexivity. Dialogic conversation is observed when individuals engage in conversation to create meaning and relevance about authentic activities. It is used to create open dialogs and establish trust and rapport. Metacognition encourages the development of critical consciousness by facilitating the development of critical thinking skills. In addition, metacognition entails critically reflecting on one’s epistemology and sense of agency. Reflexivity is used to contrast preexisting beliefs with varying points of view. More specifically, reflexivity is used to discuss how “science knowledge is produced and
reproduced, who are (were) recognized as scientists, how their work influences society at large, and how social issues determine which scientific work is worth funding.” (p. 601).

If this orientation is applied to service-learning experiences, strategies for counterresistance include providing preservice teachers with environments that 1) allow them to interact and utilize socially relevant inquiry-based science activities with students from different sociocultural backgrounds (authentic experiences); 2) challenge them to critically examine their beliefs about diversity, science teaching, and the science curriculum (metacognition) and the facts through “readings and activities on equity and multicultural issues that encourage students to contrast their taken-for granted assumptions with alternate view points” (p. 617) (reflexivity); and 3) allow them to engage in open dialogs before, during, and after their experiences (dialogic conversations).

Much of the teaching that occurs in science courses reflect the values, culture, and norms of educators who believe that they are preparing students to function in a meritocratic society (Rodriguez, 1998a). Because many preservice teachers function under the hegemonic lens that America is a meritocracy, their beliefs can prompt them to attribute the disproportionately low academic achievement scores of students of color to cultural deficiencies (Atwater, 2000). This type of deficit thinking may cause preservice teachers to make unfair judgments about students’ abilities, intelligence and behavior and may buttress their self-efficacy beliefs regarding equitable science teaching and learning. The debilitating impact that teacher beliefs can have on students, given that these beliefs may manifest themselves through instructional practices and treatment of students (Gilbert & Yerrick, 2001; Delpit, 1995), must be acknowledged. By acknowledging
these beliefs, teacher educators can provide preservice teachers with environments that challenge and/or affirm preconceived notions about the ability of diverse student groups to be successful in science. Howes (2002) has highlighted the importance of building upon the strengths (i.e. positive beliefs, attitudes, and dispositions) preservice elementary teachers bring into their science methods courses. The National Science Education Standards (NSES) underscore this sentiment by stating that teacher educators should build upon teachers’ beliefs and attitudes (NRC, 1996). Although it is important to be aware and use these strengths in developing effective science teachers, it is equally important to be aware of the weaknesses (i.e. negative beliefs, attitudes, and dispositions regarding diversity) preservice elementary teachers bring into their science methods course which may serve to marginalize diverse youth. If science teachers are to be effective in educating today’s youth, and science teacher educators are to build upon preservice teachers’ preexisting beliefs and attitudes (NRC, 1996), it is recommended that science education reform initiatives explicitly speak to the interrelatedness of preservice teachers’ beliefs about diversity and science teaching.

It is difficult to influence teachers’ beliefs and attitudes with one course. Banks (1991) states:

A transformative curriculum cannot be constructed merely by adding content about ethnic groups and women to the existing Eurocentric curriculum...When the curriculum is revised using either an additive or an infusion approach, the basic assumptions, perspectives, and values of the dominant curriculum remain unchallenged and substantially unchanged, despite the addition of ethnic content (p. 130)

Instead of compartmentalizing diversity as a separate issue which is to be addressed in one teacher education course, it is recommended that teacher education programs interweave diversity discussions and critical reflection into the course curriculum.
Addressing the needs of students from diverse backgrounds, a characteristic of many urban schools, is something preservice teachers indicate they feel least prepared to handle. Because few teachers live in neighborhoods similar to those of their students (Ladson-Billings, 1994), they often have little to no knowledge of what to expect from students who have different sociocultural backgrounds than themselves. Community-based service-learning was an effective instrument that afforded preservice teachers an opportunity to interact with students from diverse sociocultural backgrounds, practice their skills and apply what they have learned, and develop beliefs and attitudes that were congruent with science reform initiatives. Preservice teachers who participated in community-based service-learning explicated beliefs of equity that were more congruent with its true definition, treating students fairly by taking into account differences (Atwater, 2000; Banks, 2002; Lee, 1999). They also became more patient and developed empathy for the students they were working with. This is important because caring and patient teachers have been shown to be more effective facilitating the cognitive growth of diverse youth (Gay, 2000). Furthermore, these beliefs are analogous to the equity principle explicated in reform documents (AAAS, 1989; NRC, 1996; NSTA, 2004).

Although a few teachers may have been negatively affected by their service-learning experience, the majority of teachers implied that this experience provided them with what might be called a ‘critical lens’ to deconstruct, reconstruct, and accommodate new beliefs that are requisite to providing students with equitable learning opportunities in science education. Therefore, it is recommended that science teacher education programs use community based service learning as a tool for developing multicultural and reflective practitioners. However, to determine a fuller account of the effects of
community-based service-learning, it is recommended that some of this study’s limitations be addressed.

Recommendations for Future Research

The primary purpose of this study was to investigate the effects of community-based service-learning on preservice elementary teachers’ self-efficacy beliefs about equitable science teaching and learning. As much as this study provides strategies for positively influencing preservice teachers’ pedagogical beliefs and self-efficacy beliefs about equity and science teaching and learning, it also leads to some recommendations for future research. One of the emergent findings of this research study was preservice elementary teachers’ inability to differentiate the term race/ethnicity from culture and/or language. Therefore, additional research needs to be conducted regarding 1) preservice teachers’ definitions of race, ethnicity, and culture; and 2) preservice teachers’ beliefs about the interconnectedness of students’ racial/ethnic backgrounds and science teaching. Additionally, case studies should be conducted with preservice teachers’ of color in order to obtain in-depth perspectives on their experiences in science education.

Second, besides Ritter et al. (2001), no other study has utilized the Self-Efficacy Beliefs about Equitable Science Teaching and Learning (SEBEST) instrument. Accordingly, additional research needs to be conducted with preservice elementary teachers using the SEBEST to measure changes in their self-efficacy beliefs as it relates to equity in science teaching and learning. In addition, large sample sizes should be used in order to increase the study’s effect size and power.

Third, no longitudinal study has been conducted to document the long-term effects of community-based service-learning on preservice elementary teachers’ self-
efficacy beliefs about equitable science teaching. Similarly, few longitudinal studies have been conducted to determine the long-term effects of community-based service-learning on preservice elementary teachers’ beliefs about multicultural science teaching. Therefore, additional research needs to be carried out in order to determine what long effects, if any, community-based service learning has on preservice elementary teachers’ self-efficacy beliefs about equitable science teaching and their beliefs about multicultural science teaching.

Finally, few studies have investigated the effects of service-learning on preservice elementary teachers’ self-efficacy beliefs and pedagogical beliefs about equitable science teaching and learning. Since preparing teachers for educating diverse youth is an important goal of science reform initiatives, and service-learning has been found to be an effective tool for preparing teachers for the complexities of teaching diverse populations (Barton, 2000; Wade, 2000), additional research needs to be conducted on the effects of service-learning on preservice elementary teachers’ beliefs about equitable science teaching.
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Appendix A: Pre-Questionnaire/SEBEST Survey Instrument

Section I: Background Information

1. Last four digits of student identification number ________

2. Age: _____ 18 – 21  Gender _____ F  _____ M
   _____ 22 – 24
   _____ 25 – 28
   _____ 29 +

3. Ethnicity:
d. Latino/a  e. Other

4. Language: _____ Monolingual  _____ Bilingual  _____ More than two

5. Social Class Level:
   a. Lower Class  b. Working Class  c. Middle Class  d. Upper Class

6. Undergraduate or Graduate Level:

7. Are you currently interning? _____ If yes, what is the level of your internship? _____

8. As a future teacher of elementary science to diverse student groups, please rate how you currently view your own effectiveness.
   a. Extremely effective  b. Very effective  c. Moderately effective
d. Somewhat ineffective  e. Extremely ineffective
**Appendix A (Continued)**

**Section II: Attitudes and Beliefs**
Please indicate the degree to which you agree or disagree with each statement by circling the appropriate letters to the right of each statement.

<table>
<thead>
<tr>
<th></th>
<th>STRONGLY AGREE</th>
<th>AGREE</th>
<th>UNDECIDED</th>
<th>DISAGREE</th>
<th>STRONGLY DISAGREE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. I will be able to effectively teach science to children whose first language is not English.</td>
<td>SA</td>
<td>A</td>
<td>UN</td>
<td>D</td>
<td>SD</td>
</tr>
<tr>
<td>2. Girls can learn science if they receive effective science instruction.</td>
<td>SA</td>
<td>A</td>
<td>UN</td>
<td>D</td>
<td>SD</td>
</tr>
<tr>
<td>3. I do not have the ability to teach science to children from economically disadvantaged backgrounds.</td>
<td>SA</td>
<td>A</td>
<td>UN</td>
<td>D</td>
<td>SD</td>
</tr>
<tr>
<td>4. Even when teachers use the most effective science techniques in teaching science, some Native American children cannot achieve in science.</td>
<td>SA</td>
<td>A</td>
<td>UN</td>
<td>D</td>
<td>SD</td>
</tr>
<tr>
<td>5. I can do a great deal as a teacher to increase the science achievement of children who do not speak English as their first language.</td>
<td>SA</td>
<td>A</td>
<td>UN</td>
<td>D</td>
<td>SD</td>
</tr>
<tr>
<td>6. Good teaching cannot help children from low socioeconomic backgrounds achieve in science.</td>
<td>SA</td>
<td>A</td>
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<tr>
<td>7. I will be able to meet the learning needs of children of color when I teach science.</td>
<td>SA</td>
<td>A</td>
<td>UN</td>
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</tr>
<tr>
<td>8. Girls are not as capable as boys in learning science even when effective instruction is provided.</td>
<td>SA</td>
<td>A</td>
<td>UN</td>
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<td>SD</td>
</tr>
<tr>
<td>9. I do not know teaching strategies that will help children who are English Language Learners achieve in science.</td>
<td>SA</td>
<td>A</td>
<td>UN</td>
<td>D</td>
<td>SD</td>
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<tr>
<td>10. Effective science teaching can help children from low socioeconomic backgrounds overcome hurdles to become good science learners.</td>
<td>SA</td>
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<tr>
<td>11. I can help girls learn science at the same level as boys</td>
<td>SA</td>
<td>A</td>
<td>UN</td>
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<td>SD</td>
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<tr>
<td>12. Some children of color cannot achieve in science.</td>
<td>SA</td>
<td>A</td>
<td>UN</td>
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<tr>
<td>13. I do not know how to teach science concepts to children who speak English as a second language.</td>
<td>SA</td>
<td>A</td>
<td>UN</td>
<td>D</td>
<td>SD</td>
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<tr>
<td>14. Effective science teaching cannot improve the science achievement of children from impoverished backgrounds.</td>
<td>SA</td>
<td>A</td>
<td>UN</td>
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<tr>
<td>15. I will be effective in teaching science in a meaningful way to girls.</td>
<td>SA</td>
<td>A</td>
<td>UN</td>
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<td>SD</td>
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<tr>
<td>16. Children of color can succeed in science when proven science teaching strategies are employed.</td>
<td>SA</td>
<td>A</td>
<td>UN</td>
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<td>SD</td>
</tr>
<tr>
<td>17. I will have the ability to help children from low socioeconomic backgrounds be successful in science.</td>
<td>SA</td>
<td>A</td>
<td>UN</td>
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<tr>
<td>18. Children who speak English as a second language are not able to achieve in science even when the instruction is effective.</td>
<td>SA</td>
<td>A</td>
<td>UN</td>
<td>D</td>
<td>SD</td>
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<tr>
<td>19. I will be able to successfully teach science to Native American children.</td>
<td>SA</td>
<td>A</td>
<td>UN</td>
<td>D</td>
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<tr>
<td>20. Girls have the ability to compete academically with boys in science when they receive quality science instruction.</td>
<td>SA</td>
<td>A</td>
<td>UN</td>
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<tr>
<td>21. I will not be able to teach science to children who speak English as a second language as effectively as I will to children who speak English as their first language.</td>
<td>SA</td>
<td>A</td>
<td>UN</td>
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<td>SD</td>
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<tr>
<td>22. Children of color cannot learn science as well as other children even when effective science teaching instruction is provided.</td>
<td>SA</td>
<td>A</td>
<td>UN</td>
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<td>SD</td>
</tr>
<tr>
<td>23. I cannot help girls learn science at the same level as boys.</td>
<td>SA</td>
<td>A</td>
<td>UN</td>
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<td>SD</td>
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<tr>
<td>24. A good science teacher can help children from impoverished backgrounds achieve in science at the same level as</td>
<td>SA</td>
<td>A</td>
<td>UN</td>
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<td>SD</td>
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<td>children from higher socioeconomic backgrounds.</td>
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<tr>
<td>25. I will be able to effectively monitor the science understanding of children who are English Language Learners.</td>
<td>SA</td>
<td>A</td>
<td>UN</td>
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<td>SD</td>
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<tr>
<td>26. Girls can develop in science at the same level as boys if they receive science instruction that is effective.</td>
<td>SA</td>
<td>A</td>
<td>UN</td>
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<td>SD</td>
</tr>
<tr>
<td>27. I will not be able to successfully teach science to Asian children.</td>
<td>SA</td>
<td>A</td>
<td>UN</td>
<td>D</td>
<td>SD</td>
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<tr>
<td>28. Girls do not have the ability to learn science as well as boys, even when effective teaching techniques are used.</td>
<td>SA</td>
<td>A</td>
<td>UN</td>
<td>D</td>
<td>SD</td>
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<tr>
<td>29. I will be able to successfully teach science to children of color.</td>
<td>SA</td>
<td>A</td>
<td>UN</td>
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<td>SD</td>
</tr>
<tr>
<td>30. Children who are English Language Learners do not have the ability to be successful in science even when the science instruction is effective.</td>
<td>SA</td>
<td>A</td>
<td>UN</td>
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<tr>
<td>31. I will be able to help girls learn science.</td>
<td>SA</td>
<td>A</td>
<td>UN</td>
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<td>SD</td>
</tr>
<tr>
<td>32. White children can learn science as well as other children when effective science teaching is employed.</td>
<td>SA</td>
<td>A</td>
<td>UN</td>
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<td>SD</td>
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<tr>
<td>33. I will not be able to teach science successfully to White children.</td>
<td>SA</td>
<td>A</td>
<td>UN</td>
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<td>SD</td>
</tr>
<tr>
<td>34. Children who are English Language Learners can be successful in learning science if the teaching is effective.</td>
<td>SA</td>
<td>A</td>
<td>UN</td>
<td>D</td>
<td>SD</td>
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</tbody>
</table>
Appendix B: Science Self-Efficacy Pre-Interview Questions

The purpose of this interview is to understand your beliefs about teaching science. There are no right or wrong answers to the following questions or statements. The answers from all the people we interview will be combined for a research study. Nothing you say will ever be identified with you personally. If you have any questions during the interview, please feel free to ask? Do you have any questions before we begin?

1. Describe your experiences in your science classes during elementary school.
   High school. College.

2. Describe the characteristics of an effective science teacher.

3. Describe what experiences, if any, you’ve had teaching science.

4. How, if at all, will your students’ racial/ethnic backgrounds affect your science teaching?

5. How, if at all, will your students’ social class backgrounds affect your science teaching?

6. How, if at all, will your students’ language background affect your science teaching?

7. How, if at all, will your students’ cultural backgrounds affect your science teaching?

8. How would you define equity?

9. What do you think equity means when teaching science?

10. How would you define/describe multicultural science teaching?

11. That covers the things I wanted to ask. Anything you care to add?

Note: If the responses to a given question are incomplete, ambiguous, or contradictory to earlier statements, ask for elaboration or collaboration by asking such questions as:
   • Would you please elaborate on that?
   • Could you say some more about that?
Appendix B (Continued)

- I’m not sure I understand what you meant about that. Would you elaborate, please?
- I want to make sure I understand what you’re saying. I think it would help me if you could say some more about that.
- How did that experience change your thinking about [x]
- Can you provide an example of [x]?
- What would [x] look like in action?
Appendix C: Science Self-Efficacy Post-Interview Questions

The purpose of this interview is to understand your beliefs about teaching science. There are no right or wrong answers to the following questions or statements. The answers from all the people we interview will be combined for a research study. Nothing you say will ever be identified with you personally. If you have any questions during the interview, please feel free to ask? Do you have any questions before we begin?

1. How did you feel about the idea of teaching science to a diverse population of elementary school students at the beginning of the semester?
2. Now, let me ask you to think about any changes you see in yourself as a result of participating in this course. How, if at all, has your attitude changed?
3. What specific experiences, if any, contributed to this change?
4. Can you describe for me your experiences teaching science this semester?
5. Describe the characteristics of an effective science teacher.
6. How, if at all, will your students’ racial/ethnic backgrounds affect your science teaching?
7. How, if at all, will your students’ social class backgrounds affect your science teaching?
8. How, if at all, will your students’ language background affect your science teaching?
9. How, if at all, will your students’ cultural backgrounds affect your science teaching?
10. Define/Describe multicultural science teaching. What would it look like in action?
11. How would you define equity?
Appendix C (Continued)

12. What do you think equity means when teaching science?

13. That covers the things I wanted to ask. Anything you care to add?

Note: If the responses to a given question are incomplete, ambiguous, or contradictory to earlier statements, ask for elaboration or collaboration by asking such questions as:

- Would you please elaborate on that?
- Could you say some more about that?
- I’m not sure I understand what you meant about that. Would you elaborate, please?
- I want to make sure I understand what you’re saying. I think it would help me if you could say some more about that.
- How did that experience change your thinking about [x]?
- What would [x] look like in action?
Appendix D: Science Methods Post-Questionnaire

Impact of science methods course

The purpose of this questionnaire is to understand what effect, if any, the course had on your ability to teach science to diverse populations. There are no right or wrong answers to these questions and your responses will remain confidential. The term “diverse populations” refers to students from different racial/ethnic, social class, language, and cultural backgrounds.

Last 4 digits of ID# __________

Please indicate what type of effect the following course experiences had on your ability to teach science to diverse populations. Circle the number that best represents your response: 1 – negative effect, 2 – somewhat negative, 3 – neither positive nor negative, 4 – somewhat positive, 5 – positive.

1. Course assignments
2. Course readings
3. Textbook
4. Course instructor
5. Cooperative group work
6. Field experiences (Working with kids, field observations)
7. Evaluative Feedback
8. Instructor modeling science lessons

9. Please list any additional experiences that have had a positive effect on your ability to teach science to diverse populations.

10. Please list any additional experiences that have had a negative effect on your ability to teach science to diverse populations.
Appendix D (Continued)

11. What specific experiences, if any, had a positive effect on your ability to teach science to:

   a. Racial/Ethnic minorities: __________________________________________
      ________________________________________________________________
      ________________________________________________________________

   b. ESOL students: ______________________________________________
      ________________________________________________________________
      ________________________________________________________________
      ________________________________________________________________

   c. Students from different cultural backgrounds: ______________________
      ________________________________________________________________
      ________________________________________________________________
      ________________________________________________________________

   d. Students from different social class backgrounds: ____________________
      ________________________________________________________________
      ________________________________________________________________

12. What specific experiences, if any, had a negative effect on your ability to teach science to:

   Racial/Ethnic minorities: __________________________________________
   ________________________________________________________________
   ________________________________________________________________

   a. ESOL students: ______________________________________________
   ________________________________________________________________
   ________________________________________________________________
Appendix D (Continued)

b. Students from different cultural backgrounds: ______________________
   _________________________________________________________________
   _________________________________________________________________

   c. Students from different social class backgrounds: _________________
   _________________________________________________________________
   _________________________________________________________________

13. How has this experience better prepared you to teach science to diverse student
groups?

14. As a future teacher of elementary science to diverse student groups, please rate
how you currently view your own effectiveness.
   a. Extremely effective   b. Very effective   c. Moderately effective
   d. Somewhat ineffective e. Extremely ineffective

15. Please explain why you rated your effectiveness (refer to your answer to #14) the
way you did. You may use the back if necessary.

241
## Characteristics of Effective Science Teaching

<table>
<thead>
<tr>
<th>ID</th>
<th>Pre-Interview</th>
<th>Post-Interview</th>
</tr>
</thead>
<tbody>
<tr>
<td>Erika</td>
<td>I think it’s a type of teacher, just using my high school experiences, it’s a type of teacher that asks you a question and the question makes you, like you think about the question for like days. They just don’t give you the answers, but they make you explore it on your own and then when finally do find the answer, it’s more gratifying in the end. So I think it’s the type of teacher that makes you go out and find the answer instead of giving you all the answers. Um. I think also, not just using the book as a resource. But, given us options. Like if you want to know, go talk to doctors. If you want to know, sit in and watch.</td>
<td>I think honestly, it’s Instructor Roberts. Like everything that Instructor Roberts, I just love Instructor Roberts because I feel like you have the credentials, you have to be confident. You have to understand the fact that you know, I was wrong in this, I’m sorry, how can we fix this. And the knowledge that we saw in her was portrayed through the activities she gave us, not through the credentials that she told. Just having the credentials and at the same time being humble. On top of that, embracing students in their diversity and accepting, okay this child is going through a lot. What can I do? How can I modify my lesson plan to pull this child in?</td>
</tr>
<tr>
<td>Jason</td>
<td>They have to actually have some sort of excitement about the subject. They need to be a hands-on type of person because science I don’t think can be taught very well out of the book. You gotta be, even if it’s not like hands on, it’s gotta to be sort of a visual. They have to be open minded. They can’t think that their way is the only way of doing it.</td>
<td>An effective science teacher is flexible, knowledgeable, and open-minded and patient. Just basically an emphasis on the open-mind, the flexible and the patient part. You don’t necessarily have to be knowledgeable, but you have to be able to put forth the effort to learn it at the time. Open-minded means that your way is not the only way that it can be interpreted. Everybody interprets it their own way. Just basically saying that how you see, how you understand something, doesn’t necessarily have to be how somebody else is going to understand it.</td>
</tr>
</tbody>
</table>
Maria

One that knows the subject area. And one that is open-minded to children’s necessities, like abilities culturally and linguistically, to be able to...so they won’t feel like I felt. To be able to be there and make sure that each and every one of them understand what’s going on and if they need more explanation to be able to give it to them.

<p>| Maria | One that knows the subject area. And one that is open-minded to children’s necessities, like abilities culturally and linguistically, to be able to...so they won’t feel like I felt. To be able to be there and make sure that each and every one of them understand what’s going on and if they need more explanation to be able to give it to them. | One that comes prepared. One that knows of the subject area. Like if I were to come into the classroom not knowing anything about gravity, or anything about the seasons or how the moon affects our seasons and the sun and everything like that, I wouldn’t be an effective teacher. Cause I mean, I just wouldn’t be able to, you can teach kids, but if you don’t know the subject area, what are they really learning if you don’t know the subject. Being open-minded to the different behavior problems, their background knowledge. Because even though throughout the lessons sometimes we would explain or talk about the subject and they still wouldn’t understand. So, be more patient and try and explain it further so that the children understand. Open-minded as in, open to the different backgrounds, knowledge backgrounds of the kids. Open-minded as in open to the kids, I don’t know, home environment and maybe they’re not able to concentrate well because something happened at home and just being more aware of the kids situations and that eventually will affect their productivity in the classroom. |</p>
<table>
<thead>
<tr>
<th>Sarah</th>
<th>Someone who loves what they’re doing and who is very passionate about it. And makes their students interested in what they’re passionate about. So, someone who actually displays their love for science and in turn because they love science so much, makes their students at least interested or curious about what they’re talking about or about what they enjoy. Subject knowledge, knowledge of the subject matter. Teaching correct facts; letting the students be involved in the science instead of just demonstrating this, this and this is equal to this.</th>
<th>Open to change definitely, flexible, willing to sometimes let the students lead and to allow them to research it, not just research, but to allow them to investigate what’s going on without saying okay here’s all the material and it’s exactly the way it is, cause they don’t learn as much.</th>
</tr>
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<tbody>
<tr>
<td>Erika</td>
<td>I don’t think it will neither. I’ll just tap into whatever it is they already know.</td>
<td>It’ll affect it because I feel like I’ll be intimidated by what they already know and how I have to come correct. But, I guess at the same time that’s good because it’s going to make me stay on my toes. And I should stay of my toes with every class you know. I think I’ll feel like, “they rich, so they probably already got tutors and they probably already know all of this”, and I don’t want them to be like, “we already did this”…. I guess, for me, just working with students in title 1 schools, it's more of a, I guess they have like an eagerness to learn or what not. So, I feel like, they’ll receive me with arms wide open. Cause I feel like a lot of them look at school as a safe haven, so I feel like that’s more where I’ll feel safe and confident to teach.</td>
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**Effect of Student SES on Science Teaching**
### Appendix E (Continued)

<table>
<thead>
<tr>
<th>Jason</th>
<th>It may affect it a little bit, I mean in the planning. But it really shouldn’t affect because your lessons should be geared towards all types of students. Their economic level shouldn’t affect it.</th>
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<td></td>
<td>It really shouldn’t. But, if you’re assigning homework, it depends on their social background. Like if they don’t have a computer in the home, you really can’t really assign them to do an internet assignment at home. It depends on…it’s not really their social background, it’s what they actually have and what they don’t have.</td>
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<tr>
<td>Maria</td>
<td>It wouldn’t.</td>
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<td></td>
<td>Probably, if the lesson requires for the students to bring in materials and I know that the family is struggling economically, I probably would to limit, try to limit those types of lessons where it requires the students to bring in those materials. I would try to recycle throughout the year and have those materials available for those that aren’t able to bring them in or whatever.</td>
</tr>
<tr>
<td>Sarah</td>
<td>It won’t affect it in terms of what they’re being taught. They obviously still should be taught all of the subjects in science, but it would affect it in more of a, if they don’t have any prior knowledge, schema built for science areas, then you’d have to build that schema before you could even start talking about science related things.</td>
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<td>You might now have as many resources if you’re in a lower economic area. This would affect the way in which you teach science. It would be hard to do experiments using microscopes if there were none at the school. So it would just require a lot of creativity and ingenuity so that the students are able to cover the same curriculum that students in higher SES schools can and have the same experiences if at all possible. By this I mean that it is important not to just lecture or teach in a direct instruction manner because you lack one thing or another. You just have to be creative and still allow the students to have scientific experiences.</td>
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### Effect of Student Language on Science Teaching

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<tr>
<th>Name</th>
<th>Response</th>
<th>Response</th>
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<tbody>
<tr>
<td>Erika</td>
<td>I don’t think so. And maybe I’m being naïve. But, just use things that’s going to help them with their language. Or tap into their language.</td>
<td>I don’t think it will. I guess referring back to ESOL and I just feel prepared to have a lot of modifications based on language.</td>
</tr>
<tr>
<td>Jason</td>
<td>Um. I don’t know any other languages besides English. So it would affect it in the fact that depending on what their English level is, but I would include the resource teachers and any other resources I can in getting them the proper lessons. I wouldn’t just exclude them from them.</td>
<td>I only know one language. So, it’s basically just taking the time to actually…you basically just have to figure out what their language proficiency is and what they actually have to do. You interpret their backgrounds into the lessons. Make sure the language is on a level that they can understand so they don’t feel overwhelmed. You incorporate stuff that their comfortable with into the lesson. Stuff that’s familiar. You incorporate their background knowledge, that’s it.</td>
</tr>
<tr>
<td>Maria</td>
<td>I would have to be um, let’ see, I would need more material or you know, uh in their language maybe to just make sure that they understand the lesson, but teaching, it wouldn’t affect it.</td>
<td>I would have more pictures and I guess like if there’s steps into making a project or a lesson for them to learn what a certain subject is, I would have the stops not only with pictures but less wording.</td>
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<tr>
<td>Sarah</td>
<td>If they don’t have science vocabulary that will be really hard to teach science, so you would have to break it down and just be very I guess elementary in breaking down the vocabulary and explaining what the different things are that you’re talking about so that you’re not over their head the entire time.</td>
<td>I think that can affect it a lot. Because if you do have students who don’t speak English proficiently, then you need to maybe not give them a textbook or give them a dictionary of words that they might encounter. Give them pictures instead of forcing them to read a textbook that they don’t even understand half the words in.</td>
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### Effect of Student Culture on Science Teaching

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<tr>
<th>Name</th>
<th>Response</th>
<th>Explanation</th>
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<tbody>
<tr>
<td>Erika</td>
<td>I don’t think it will neither.</td>
<td>Depending on their cultural backgrounds, it’s going to affect my self esteem, whether I’m confident or whether I’m not confident.</td>
</tr>
<tr>
<td>Jason</td>
<td>It would affect it like I said in the planning, because you don’t want everybody’s cultural background, everybody came from somewhere, so you want to try and include their cultural backgrounds in the lessons. But it’s all about tapping their prior knowledge like I said.</td>
<td>It will influence it in what I, what background I put into a lesson. Like if a student came from one country, I would try to incorporate, I can’t think of the word, but like their customs into the lesson, so basically every student can learn about where they come from, so they can understand what they’re going through, they’re customs in that country can be different than what we actually do here. So, it might bring stuff into perspective.</td>
</tr>
<tr>
<td>Maria</td>
<td>It wouldn’t affect it.</td>
<td>I would, I guess I would want to be able to incorporate people of different cultures that have come up with different subject areas or different ideas and just try to incorporate that more so that every culture is touched in my classroom.</td>
</tr>
<tr>
<td>Sarah</td>
<td>Pretty much the same.</td>
<td>Pretty much in the same way. I think it’s good to take into consideration cultural differences so that you don’t offend anybody. But, at the same time, in a way they need to know what American culture is and the where Americans teach science.</td>
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### Multicultural Science Teaching Definition

<table>
<thead>
<tr>
<th>Name</th>
<th>Statement</th>
<th>Additional Information</th>
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<tbody>
<tr>
<td>Erika</td>
<td>Back to modalities. Just teaching that will tap into every type of student background. No matter where you came from. Like the student from Haiti or the student from Africa. Just tapping into something inside of them with the schema and stuff.</td>
<td>Breaking down every stereotype. Breaking down or thinking that all old white people with glasses, white males with glasses I’m sorry, are science teachers or are scientists. So, I think it’s just teaching to everybody and not feeling like this group will know more and this group would know less. I think when everybody gets to the point when someone says “what’s the first thing you think of when you hear the word science or scientists” and everybody like writes black, white, female. When everybody gets to that point, I feel that’s when we’ll have…</td>
</tr>
<tr>
<td>Jason</td>
<td>Teaching all backgrounds, all, never have a one-sided view. Try to give the whole picture instead of just one dimensional.</td>
<td>Multicultural would be somebody that incorporates different cultures into their lessons and teaches about customs and where science came from, from different cultures. Like this country was responsible for contributing this to science. Basically all the countries and what their contributions were to science.</td>
</tr>
<tr>
<td>Maria</td>
<td>I guess, presenting students with scientists or people who have some experiments and stuff like that are all diverse cultures.</td>
<td>Incorporating the different diverse, diverse and different cultures of different scientists. And activities that involve I guess for the different learning levels.</td>
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Appendix E (Continued)

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<tr>
<th>Sarah</th>
<th>I’d saying teaching not only things that maybe your stereotypical scientist has discovered but making sure to include female scientists and scientists of other races, from different countries and including the different. Because a lot of science that we think of as Americanized science really has its origins in other countries, so making sure to include those other countries and races.</th>
<th>Teaching science not only to all races, ethnicities, social classes, but teaching them about their I guess, how their culture is involved in science and/or how their ethnicity has been involved in science. Letting them know that their race or ethnicity or even social class has made an impact on science.</th>
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<tr>
<td>Erika</td>
<td>like science can fall in all different spectrums. Like you can have black woman that’s a scientist. You can have a handicapped person that’s a scientist. Don’t just limit science to the Anglo Saxon person with the crazy hair. So I guess it just falls on every spectrum.</td>
<td>To be equal across the board, every ethnic group. Okay, if I have an Indian student, an African student and an American student all in my class, the way that I present science will be in a way that accommodates to all of my students. The Indian student understands, the African student understands and American student understands. I’m not just catering to the American student since I’m American.</td>
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<tr>
<td>Jason</td>
<td>How much time you spend on it. How much planning you put into it. How much excitement you put into it. How much personal belief you put into it.</td>
<td>Equity in science is how much information you put into a science lesson. How accurate it is. If it’s not accurate, it’s not worth very much. Equity is worth. How much the lesson is actually worth to the students, how much they got out of it. You got to put effort into it to get effort out.</td>
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*Equity in Science Teaching*
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<tr>
<th>Maria</th>
<th>To be equal in teaching one student the same as the child of another backgrounds.</th>
<th>Being fair with all my children, all the students. That just because they come from a lower socioeconomic background, that doesn’t mean that they’re not capable of learning. I would make sure that my lessons, or that my students are challenged. That I wouldn’t…I mean challenged to a point where they can actually get it. Hopefully, I’ll know my students well enough to see where their learning abilities are. So, I would try to build on that and be fair with all of my students in that aspect.</th>
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<tr>
<td>Sarah</td>
<td>That you give all of your students, regardless of socioeconomic status, gender, race, language barriers, you give them all an equal opportunity to learn. That you break it down for those students who need it to be broken down. You challenge those students who need to be challenged and you give them all an equal opportunity to learn, maybe not exactly the same material, or the same level of things. But that you give them all the opportunity to learn as much as that specific student can.</td>
<td>Equity is not giving the same educational experience to every child (meaning exact same curriculum, way of teaching, experiments, materials etc.) but it is giving an equal opportunity. This means that you have to teach the way your particular students learn and that you have to teach in a way that allows your students to learn. You also have to use the materials your school gives you (or go out and buy your own and on a teacher's salary that is unlikely!). You have to strive to give every student a chance at learning to the best of their own ability and not force them to learn the same way their neighbor does.</td>
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## Characteristics of Effective Science Teaching

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<tr>
<td>Natalia</td>
<td>Involving, engaging…for me they have to grasp my attention the minute I get in there. If not, I’m so lost.</td>
<td>You have to be engaging. You have to be knowledgeable [of content], understanding, and basically being understanding and engaging will really help you. Planning ahead of time, researching the content and then being confident and going up there and saying, you know I’ve learned all that we’re going to teach you, so I’m good, I can do this.</td>
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<tr>
<td>Kim</td>
<td>Organized, prepared, activities developed to get the kids to understand science, because some concepts are harder. I love the hands on activities, like all the labs and stuff, I think is excellent. I think respectful and like appreciative of the students. Like if they don’t get it or something, they help them and guide them.</td>
<td>I think they need to have class management and be organized. I think they need to provide like hands on learning, not all just book work. I think they need to be considerate of everybody in the classroom, like of every student and try to modify it to their needs.</td>
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<tr>
<td>Angel</td>
<td>I guess…I would say...An effective science teacher would be one that makes the students enjoy science, makes them see the different ways that you do science in real life. I guess I would say an effective would see that science…an effective will help you see that all subjects are intertwined including science, so, that will make you feel that science is connected with everything else.</td>
<td>An effective science teacher is one that will make you leave and enjoy the subject of science. And one that will make you want to get engaged in science activities. Make you want to, like, experiment with different things. Things you would have never thought of experimenting with, like pop corn and just see it in a scientific way. Considering the students feelings. Not making them feel like you’re always telling them what to do. Just make them feel like they’re creating something as well, they have input.</td>
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<tr>
<td>Laura</td>
<td>Umm…I had a question like that and I believe it was from math or something. An effective teacher I would say are critical thinkers, they reflect, they’re there to convey information to you not impose ideas but to offer them and expose you to information you wouldn’t normally know.</td>
<td>Definitely, being knowledgeable of the content. You should definitely know exactly what is true and offer facts, have the children figure it out for themselves, offer them problems so they can figure out the solution. You can always assist them. Definitely, keep an open-mind to offer them things that are diverse. Not just something in America even, for example, you can study something that’s related to Africa or India or Japan. So, just offering a wide variety of interests to interest all students. Enthusiastic. Someone that’s happy. Someone that the students get there and they’re obviously happy to see the students. And someone who’s motivating, challenging, definitely pays attention to progression and the needs of students. Cause sometimes a student might be asking for help, and subtly you notice that they’re slacking in one part of a certain area, so definitely being attentive.</td>
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<tr>
<td>Angel</td>
<td>Hmm…I don’t know…like I think about me and where I am right now, in this classroom (science methods course) and I feel like I don’t count. I say that I’m the only black person in this class. So I think about me and my future classroom and I wonder, cause I hate it, the way the classroom is right now. And I wonder if all my students are white, how would it feel…how would I like it…I don’t I would like it, that’s why I want to teach at a…I want to teach at a school where…I would rather teach at a school that had black students than white student.</td>
<td>It wouldn’t affect my science teaching. It would just include different examples of the different cultures. It won’t just focus on American culture and science.</td>
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### Effect of Student SES on Science Teaching

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<td>Laura</td>
<td>I would just offer diversity, you know? Like most mainstream schools don’t offer information for the minority that they give for the mainstream dominant culture, so I would just offer it. Posting pictures besides Einstein up in the classroom. So little things like that, just so they know that there are people like them out there that have um accomplished things.</td>
<td>I think it will affect it in a good way. Because they’re all coming from different perspectives and that is one way you learn is to learn how other people think and how perspectives are created and just how people learn. I think that’s a good way to offer students new knowledge. Cause if you ask one child and you know, how they think a problem is solved and then you asked the other, then you could have them work together and have them figure out what the real answer is. But at the same time, just hearing that way of thinking, it’s a different process from the other students so, I think that’s definitely a good thing.</td>
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<tr>
<td>Natalia</td>
<td>No.</td>
<td>It shouldn’t affect it at all. If they’ve never been exposed to something, then give them the opportunity to learn something new. If they can’t afford the material, then don’t put them in a situation where they have to buy the materials. If I can’t provide them, the school can’t provide them, then it won’t be done.</td>
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<tr>
<td>Kim</td>
<td>Um. Maybe bringing in supplies and stuff. But I think that I would try and work around that because I know a lot of people who give free supplies.</td>
<td>Well, if they’re a poor social class, obviously we can’t have like all the material, maybe like higher social classes might be able to bring in. So, that can always limit lessons and activities. It will also limit like home activities. If I send them different home, that will, social classes will definitely mess up what’s allowed, like technology is a huge one that will be affected.</td>
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Appendix F (Continued)

| Angel | I don’t think it will. | I don’t think it really will affect my science teaching because I want to teach at an inner city school and I feel like I’m just going to provide everything that I possibly can and if they ever have to purchase anything and can’t, they will always be able to come to me and just let me know. But, I won’t ever ask them to purchase something that is expensive. |
| Laura | I would offer diversity you know. And offer supplies and things like that, because not every child has been to the beach or has the money to buy like that poster board or things like that, so I would definitely keep an open door policy so they can come and speak to me. | Hopefully, they will not at all. I mean I know that students are coming from different environments and different situations, but hopefully once they come to my classroom, it will be a safe neutral environment so that all of them can learn. |

**Effect of Student Language on Science Teaching**

<p>| Natalia | That one you know, just having a couple of classes on how to approach it would help, I would think because they’re going to be totally lost. Just having the proper approaches and engaging them. | Try to translate or get somebody that can translate for them. |
| Kim | They might not be able to understand all the activities, obviously. They’re definitely not understanding the material. I guess I would have to use my ESOL strategies, or ones I will learn. | Well, it will affect it if I’m teaching a lesson that don’t recognize a word that’s common to us that’s not common to them, or they can’t place it in like a meaningful sense. I mean I guess the same kind of example will go with the home activity. If you send some of them home and there’s a language barrier, it may not come across as easy when they’re on their own or with the parents either. |</p>
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<thead>
<tr>
<th>Angel</th>
<th>It wouldn’t affect my science teaching.</th>
<th>I would just, you know just everything that I’m learning in my ESOL classes and just everything that I’ve learned from experience with helping my grandmother understand something that I’m telling her. Just using pictures, and ways of communicating with them. With different languages, I want it to be an exchange. Like I have a student in my class that only speaks this language and she’s learning English and I don’t want her to feel like we’re making her learn English, and I feel like if she’s in our class we can learn some things from her language. Like, that’ll make her feel like we want to know about her language. It’s not like we want you to change who you are and don’t want to ban that language that you speak in this classroom.</th>
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<tr>
<td>Laura</td>
<td>I would just try and be more specific, give examples, gestures, umm...few words, vocabulary, try and offer so that they can understand and be able to relate it to their lives so that it can become part of their vocabulary and language.</td>
<td>Again, like I really want to brush up on languages and I’ve taken ESOL 1, but taking ESOL 2 this summer, I think that will help, just learning different ways to get them to understand certain ideas. Whether it’s with pictures or acting it out or working with other students that are English proficient. I think that’s it’s very important you know cause they’re in our classroom, but some time they’re going to be in the real world. So, it’s here in the classroom where they need to learn.</td>
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<tr>
<td>Natalia</td>
<td>I wouldn’t view as anything, unless they have something that prevents them, like their religious beliefs or some kind of background where things aren’t done a certain way or they don’t believe in…whatever it is. Then that would be an issue that you have to address on a day by day basis, but I don’t see…I don’t foresee anything.</td>
<td>Respect if there’s something that is not acceptable to them.</td>
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<tr>
<td>Kim</td>
<td>I think it’d be used in a positive way. Like bring in all different cultures together. Um. We had an idea in my level 1 intern of doing like a cookbook of different cultures. So, that would be like an idea, cooking kind of goes along with science.</td>
<td>It will affect it if I’m teaching a lesson that and they don’t recognize a word that’s common to us that’s not common to them, or they can’t place it in like a meaningful sense. I guess the same kind of example will go with the home activity. If you send some of them home and there’s a language barrier, it may not come across as easy when they’re on their own or with the parents.</td>
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<tr>
<td>Angel</td>
<td>None.</td>
<td>It’ll just include, I would try to include different cultures and not focus on one culture in my classroom.</td>
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<tr>
<td>Laura</td>
<td>In a positive manner. I think that diversity is one of the best things that you know this world has to offer, so I would just take it and use it as a tool.</td>
<td>I think, again, as I’ve said, I think that diversity and culture is positive. And I think that each student learning from the other. Whether, it’s about tradition or just learning together because they’re two different people putting their minds together. I think that’s a positive thing. I think they have two different sides to offer.</td>
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<tr>
<td>Name</td>
<td>Multicultural Science Teaching Definition</td>
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<tr>
<td>Natalia</td>
<td>I would define it as making sure everybody feels represented and not keeping or having a certain culture dominating the subject. I would probably define it as (pausing) that’s a good one, teaching science within many cultures. You have to be aware of the people’s cultures to be able to respect and know how to engage your students. It all depends on the cultures that I would have. If it’s a classroom for example of Hispanic students, I may teach them with something in Texas for example, in north Mexico, we have a pig that they call the havelina. I think it’s a boar. But they call them havelina, that’s their name. So, maybe I would say today we’re going to learn about a havelina and then say this is a boar. It’s a wild pig, elaborate on that.</td>
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<tr>
<td>Kim</td>
<td>Teaching science that incorporates several cultures to all students. Teaching students not only science content, but the methods of learning in a diverse population through several different perspectives...cultures.</td>
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<tr>
<td>Angel</td>
<td>Multicultural science teaching I believe is doing experiments that not only relate to one culture. Yeah, like multicultural science experiences would be I would do things from that culture and include the different cultures that are in my classroom and the ones that aren’t in my classroom. Multicultural science teaching is science teaching that includes multiple views and perspectives and angles of different cultures on the subject of science.</td>
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<tr>
<th>Laura</th>
<th>Offering different types of teaching styles. Whether it’s for an auditory learner or a visual learner. Just offering the whole spectrum of ways that children learn and culturally. Whether it be a home activity like cooking something with your mom, measuring this, measuring that, where you could interrelate culture in to it.</th>
<th>I just think that offering a wide variety of diversity, different people. You don’t have to just study Einstein. You don’t even have to study Einstein, but just offering different people and different knowledge. Because Einstein knew this, he might not have known this over here. You can even compare the two. I would [also] have students work together because if there were three Caucasians, they’re not the same people. They’re still diverse. They have three different cultures. I would try my hardest to show different perspectives cause they are the learner. They’re the researcher. And definitely show them that they’re all capable.</th>
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<tr>
<td>Natalia</td>
<td>I would think that it would be building confidence. Knowledge...bridging all those gaps and things that we believe that students can achieve.</td>
<td>I really don’t know. I can’t think of a...of a good answer for equity of science. I would have to guess that it means giving everybody an equal opportunity. But I really don’t know.</td>
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<tr>
<td>Kim</td>
<td>Teaching everybody the same. Getting them all on the same level.</td>
<td>I have no idea</td>
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<tr>
<td>Angel</td>
<td>Making sure that everything is fair...I don’t know</td>
<td>Equity means, basically seeing it in all different angles. For example, there’s not one way to do an experiment. There’s not one way to come up with the same result.</td>
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Laura  | Equity when teaching science. I guess using numbers effectively whether it be the number of trials you do an experiment; the time you would use; the time limit for each experiment or group number.  
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<td>I’m going to say being fair to the students. Showing them that everyone is equal. Whether it be bringing in diversity and studying someone from Japan or China or showing them that his perspective, this perspective, is the same, or not the same, but as equal as the other. Just showing them that everyone is on the same level of equality and that everyone’s ideas are important and add to what we’re learning or talking about.</td>
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## Appendix G: Section Three Preliminary and Post-Interview Excerpts

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<th>ID</th>
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<tr>
<td>Eric</td>
<td>I would think the thing that separates any effective teacher from a mediocre teacher is their level of passion that they bring into the classroom.</td>
<td>An effective science teacher has to set the guidelines for their students. Just set the parameters for the students to work within. And at some point, when all the directions are given, they have to step back and allowed the students to explore for themselves. They can’t guide all of the procedures to the tee. They should be able to step back and allow the students to make their own hypothesis and assign themselves roles. It would be wise for the teacher to set some sense of roles for the students. Just allow them to start working on their own and making their own discovery rather than having the teacher provide all the answers for them. An effective teacher should be able to set an environment in which the students’ ideas are welcomed. I guess just with the classroom management, they have to have a sense of order.</td>
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<tr>
<td>Michael</td>
<td>Someone who could relate the things you learn to your life, connect with you as a person out of the classroom.</td>
<td>A willingness to learn along with the students. Openness to new ideas. Confident in your own ability and I think preparation is a good thing. Relating to the students is always a good thing for everything.</td>
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<tr>
<td>Robin</td>
<td>Passionate…because if the teacher is passionate about what they’re doing it will reflect on their students. Patient…involved…I’m real big on hands-on.</td>
<td>My number one thing would be hands on. Making it fun. Patience, which I’m slowly learning.</td>
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### Appendix G (Continued)

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<tr>
<th>Kathy</th>
<th>Someone who makes the class interesting. And doesn’t just teach from the book, read this, let’s take notes, do this little experiment and move on. They need to connect it to the real world. Understanding I think. Or willing to accept other people’s ideas.</th>
<th>Someone who has knowledge of the subject matter and is able to engage students. Hands-on. I think that’s the most to get a student engaged is to do something hands on. That like allows self-exploration. Let them come to their own conclusion about things. Just kind of guide them along and stuff.</th>
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### Effect of Student SES on Science Teaching

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<tr>
<th>Eric</th>
<th>I don’t know. Just the level of resources that they have. Well, I guess like if a student comes from a home in which the parents aren’t as active in their education or aren’t as inquisitive as far as what they’re doing in the classroom or as far as their homework and stuff like that, as opposed to the student whose parents are deeply involved in their studies and deeply involved in their learning. I mean most definitely there’s going to be a huge difference in the level of reception that the student is going to have in the classroom, so I mean, that’s just one fact.</th>
<th>It should have some play in it. Just as far as, I guess them having the ability to have the supplies that are needed in the science course. I don’t want my students coming to class hungry. That could distract their performance in the science classroom. With them growing up in a single parent home, if I were to give them homework projects, I would want them to have some outside help with the projects. So, that could also play a factor.</th>
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Appendix G (Continued)

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<tr>
<th>Michael</th>
<th>I don’t think it will. I think they all can learn.</th>
<th>Generally, poorer students don’t have the background knowledge and experiences that some of the wealthier students do. So they’re going to bring different things in. Maybe some poor kids won’t have half the things that wealthy kids have, or won’t be taught. Most of their parents probably work or they don’t have parents that can help them with homework. I’d just have to find a way to get them all on the same levels. Or at least bring the kids who don’t have those experiences some of those experiences and give them that background knowledge.</th>
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<tr>
<td>Robin</td>
<td>I don’t think it will affect it either…No, not at all.</td>
<td>I don’t feel that it does. I’m sure it does and I’m sure I’m going to learn more about that.</td>
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<tr>
<td>Kathy</td>
<td>I: Um. Very little, I mean somebody from a higher backgrounds may have more experiences, so they may know different things but, I don’t think it’ll affect what I teach in the classroom cause I’ll try and make it even ground.</td>
<td>You may have to adapt a little to experiences, but I don’t…I mean if I’m really low SES area, and we’re talking about animals, I’m not going to refer to the animals in the zoo because they have no money, they don’t have the means to go to the zoo. If I was in a very wealthy place, they probably go to the zoo every other weekend. They’re nit going to be able to relate to that much more.</td>
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### Effect of Student Language on Science Teaching

| **Eric** | If we’re doing something in English, if we’re operating in the English language. If the textbooks are in English, of course if I’m writing English and a student can’t understand what I’m doing, I’m not going to say that it’s hopeless, but it’s going to be very turbulent trying to convey ideas across to those who can’t speak the English language. So, we may make some progress throughout the school year, but for starters it’s going to be very rough trying to convey ideas. Trying to communicate with those students who can’t speak the English language. I would have to go and take the initiative to supply myself with bilingual dictionaries in the class. I know that they have Spanish English dictionaries. I don’t know about Haitian Creole, if they have those. I’m pretty sure they do. Just to step up my level of proficiency of being able to make an attempt to try and establish some communication between me and my students. Also, if there’s an ESOL specialist at the school, if they aren’t too busy or if they’re available, I could bring them in to the classroom and see if they could offer their assistance in translating or just also establishing some communication between me and the student. And also, if there are students in the classroom who happen to speak the language of that student who can’t necessarily speak English that well, I could hopefully gain their assistance in helping to translate and just work with that student. |
| **Michael** | I think just having kids that don’t speak English working with other kids or a student that can speak both languages, interacting with that. | Hopefully, someone in the class speaks two languages and I can use them to translate and help kids who don’t speak English as well. It’s definitely going to be a problem. Right now I don’t really know how I’m going to do it, but hopefully by the end of this next year and a half I’ll learn. |
### Appendix G (Continued)

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<td>Robin</td>
<td>I: I think that would, possibly. It would depend on the student; how well they speak English. It won’t necessarily affect how I create the lesson but how I would present it.</td>
<td>I’ve found that a buddy system works really good with ESOL students if they can work with a student’s whose first language is English, peer learning is a lot, makes it easier for an ESOL student or an ELL to follow what’s going on, to work with someone their age. It’s so funny, when I watch it, kids have a whole different language themselves.</td>
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<tr>
<td>Kathy</td>
<td>Just the communication part. It may be hard to communicate ideas if they’re not English speakers.</td>
<td>I don’t think they’ll understand me. I don’t think they’re going to learn very much.</td>
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### Effect of Student Culture on Science Teaching

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<tr>
<td>Eric</td>
<td>Their culture may have contributed to something in science and they may want acknowledgement of that.</td>
<td>It shouldn’t affect it that much. I’ll have to present the science lesson in a way that they understand and their cultural backgrounds, it really should play a part in science. I want to say science is a universal concept in which everyone input, as long as it’s within the proper guidelines, everyone’s input has some sense of contribution to the flow of the scientific research that is being taken. It really should play a part in it. It shouldn’t play a major role in the flow of the science lesson or science classroom. I guess with their cultural backgrounds they have to put in…I see if it’s the course was philosophy or something then they’ll have more of themselves to kind of put into it.</td>
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Michael | You want to try and include their cultural backgrounds in the lessons. But it’s all about tapping their prior knowledge like I said. |
---|---|
| It will influence it in what I, what background I put into a lesson. Like if a student came from one country, I would try to incorporate, I can’t think of the word, but like their customs into the lesson, so basically every student can learn about where they come from, so they can understand what they’re going through, their customs in that country can be different than what we actually do here. So, it might bring stuff into perspective. |

Robin | I don’t think it would. |
---|---|
| Students from different cultures, you know, see lots of different things. Like a student from china wouldn’t have any idea of what a red tailed hawk looks like cause they’re not native to china. But, it definitely would make a big difference. I’d like to try and incorporate their culture in to the lesson somehow where they feel like their culture is appreciated and that it does connect to ours in a lot of ways. |

Kathy | Very minimum. |
---|---|
| I don’t think they will have an affect. |

**Multicultural Science Teaching Definition**

Eric | The teaching of science for all ethnic backgrounds. But, that still just encompass just science teaching. There has to be some distinction. As far as like, for some reason it seems like their ethnic background has to be taken into account as far as me teaching them science and I don’t …I don’t see the connection. |
---|---|
<p>| Science teaching that is geared towards instructing students of various cultures and backgrounds. I guess with the inclusion of their cultures. Again, I don’t know how science, with us being different human beings and all, and having physical differences, but I don’t know…culture goes into ethics and stuff like that and I don’t see how science and ethics, well science and ethics they do encompass one another. |</p>
<table>
<thead>
<tr>
<th>Name</th>
<th>Response</th>
<th>Additional Response</th>
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<tbody>
<tr>
<td>Michael</td>
<td>I think it means teaching so that every culture feels like their culture is being represented but putting them together so that everyone feels a part of one another and part of the same culture that has all of these cultures in it which is what the American culture is.</td>
<td>Making adaptations for all the students. Taking into account all the cultures and everything that goes along with that and giving them all an equal opportunity at one education.</td>
</tr>
<tr>
<td>Robin</td>
<td>I guess it would be uh allowing different cultures. You wouldn’t want everything you do in science to be based on your opinion…umm you might study creatures and animals from other countries…landmarks…I guess it would be a large amount of culture involved with science, so I take that back.</td>
<td>Teaching to meet or to at least recognize the different cultures of the world and that science is science, whether you’re from china or Japan or England or America, a rock’s still a rock, a mineral is still a mineral. That doesn’t change over cultures and make connections. Science is universal.</td>
</tr>
<tr>
<td>Kathy</td>
<td>I: Um I think it would mean teaching science in a multicultural way. Taking into consideration different backgrounds and styles of learning and different types of people.</td>
<td>Teaching science from all viewpoints. From men, women, all racial groups. I mean like teaching about scientists, specific scientists. I wouldn’t just teach about Einstein.</td>
</tr>
<tr>
<td>Name</td>
<td>Equity in Science Teaching</td>
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<tr>
<td>Eric</td>
<td>Equity I would think is the level of equality. I would think that all students should have a level of equity when it comes to the material being used. When it comes to the dispersing of information. The instructor should take steps that each student is on the same level of understanding as far as the ideas they are trying to present.</td>
<td></td>
</tr>
<tr>
<td>Michael</td>
<td>Equity is making sure that everyone has the same chance to do everything you don’t waste it all on one child.</td>
<td></td>
</tr>
<tr>
<td>Robin</td>
<td>Maybe like providing equal opportunity…maybe like showing them that not just white males can be scientists and that we’re all equal, we all have the same equal opportunities to become whatever we want.</td>
<td></td>
</tr>
<tr>
<td>Kathy</td>
<td>Making it work for all students and what they get out of it. The quality of what they get out of it.</td>
<td></td>
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</table>

Equal facility in which the students are able to learn. Equal attention from the instructor that is facilitating the learning. Equal amount of textbooks or supplies that are readily available for the students. Equal or fixed amount of time that the student is able to give the necessary responses to the questions being posed. Equal. Give them all an opportunity to do everything. Providing the same opportunities for all students. Making sure you have, that you make changes where needed. If you have a physically disabled student who’s in a wheel chair, you’d want a table high enough where they can sit underneath it, make accommodations. Well, I think in order to provide the same opportunities, sometimes you need to make accommodations. Providing like an equal experience for everybody. Bringing in all groups…different scientists
Appendix H: Multicultural Education and Equity Awareness Quiz

By Paul C. Gorski (gorski@earthlink.net) for EdChange and the Multicultural Pavilion
http://www.edchange.org/multicultural
http://www.mhhe.com/multicultural

Please circle the correct answer for each question. We will discuss the answers when everyone has completed the quiz.

1. According to the U.S. Census Bureau, the majority of poor children live in:
   a. urban areas
   b. suburban areas
   c. rural areas

2. According to the U.S. Bureau of Justice, between 1995 and 2001, the percentage of students reporting that they had been a victim of a violent crime in school:
   a. increased from 6% to 18%
   b. increased from 18% to 30%
   c. decreased from 25% to 3%
   d. decreased from 10% to 6%

3. What percentage of U.S. toxic waste dumps that do not comply with Environmental Protection Agency regulations are found in predominantly African American or Latino communities?
   a. 10%
   b. 50%
   c. 75%
   d. 90%

4. Which of the following variables most closely predicts how high someone will score on the SAT test?
   a. Race
   b. Region of residence
   c. Family income
   d. Parents' academic achievement
5. In a national study of college students, 27.5% of women reported that they had been the victim of a rape or attempted rape since the age of 14. What percentage of these rapes or attempted rapes was reported to police?

   a. 5%
   b. 20%
   c. 35%
   d. 50%

6. The U.S. military budget is by far the highest of any country in the world. By 2003, the U.S. military budget was roughly equal to that of:

   a. the next 5 countries combined
   b. the next 10 countries combined
   c. the next 15 countries combined
   d. the next 20 counties combined

7. How many of every thousand senior level male managers of Fortune 1000 companies are Asian or Asian American?

   a. 3
   b. 47
   c. 99
   d. 153

8. According to a Business Week study of 3,664 business school graduates, how much more, on average, does a man with an MBA from one of the top 20 business schools in the U.S. make during the first year after graduation than a woman in the same situation?

   a. About $1,500 more
   b. About $3,000 more
   c. About $6,500 more
   d. About $10,000 more

9. The two richest people in the U.S. own more personal assets than:

   a. the 10 poorest countries combined
   b. the 25 poorest countries combined
   c. the 40 poorest countries combined
   d. the 60 poorest countries combined
Appendix H (Continued)

10. Compared with schools in which 5% or less of the students are people of color, how likely are schools in which 50% or more of the students are people of color to be overcrowded (25% or more beyond capacity)?

   a. equally as likely
   b. twice as likely
   c. four times as likely
   d. six times as likely

11. Powder cocaine (largely used by wealthy white people) and crack cocaine (largely used by economically disadvantaged Latino and African American people) contain roughly the same amount of the drug per gram. How much of these substances must an individual be convicted of possessing to be sentenced to a mandatory minimum of five years in prison?

   a. 500 grams of powder or crack cocaine
   b. 50 grams of powder or 5 grams of crack cocaine
   c. 500 grams of powder or 5 grams of crack cocaine
   d. 5 grams of powder or crack cocaine

12. Children raised by single mothers attain, on average:

   a. 4 fewer years of education than children raised by two parents
   b. 2 fewer years of education than children raised by two parents
   c. the same level of education as children raised by two parents
   d. 2 more years of education than children raised by two parents

13. According to the U.S. Census Bureau, how many millionaires are there in the U.S.?

   a. roughly 3,500,000
   b. roughly 1,000,000
   c. roughly 500,000
   d. roughly 150,000

14. According to the Public Citizens Health Research Group, what percent of U.S. jails and prisons routinely hold people with a mental illness without any criminal charges?

   a. 13%
   b. 27%
   c. 45%
   d. 99%
Appendix H (Continued)

15. 97% of all students in public high schools regularly hear homophobic comments from peers. What percentage report hearing homophobic remarks from school staff or faculty?

   a. 5%
   b. 27%
   c. 53%
   d. 74%

16. What percentage of the world population regularly accesses the Internet?

   a. 2%
   b. 15%
   c. 29%
   d. 51%

17. In 1999 the average U.S. worker earned $26,105. This represents what percentage of the average CEO salary that year?

   a. 0.21%
   b. 1%
   c. 6%
   d. 17%

18. According to the U.S. Department of Education, about 61% of public school students in the U.S. are white. What percentage of public school teachers are white?

   a. 61%
   b. 73%
   c. 87%
   d. 99%

19. According to the National Survey of America's Families, how much more likely are non-elderly Hispanic adults to be without any health insurance than non-elderly white adults?

   a. twice as likely
   b. three times as likely
   c. four times as likely
   d. five times as likely
Appendix H (Continued)

20. What percentage of the U.S. Government budget goes to welfare and Social Security?

a. 25% to welfare and 25% to Social Security
b. less than 1% to welfare and 20% to Social Security
c. 20% to welfare and 1% to Social Security
d. less than 1% to welfare and less than 1% to Social Security
ABOUT THE AUTHOR

Neporcha Cone received her Bachelor’s Degree in Biology from Florida State University in 1996 and Master’s Degree in Science Education from Nova University in 2000. Prior to entering the Ph.D. program, Neporcha was a middle school science teacher for Miami-Dade County Schools for 7 years. She is gifted certified and has also taught Honors/Gifted Biology and Honors/Gifted Earth Science.

While in the Ph.D. program at the University of South Florida, Ms. Cone made several paper presentations at science education conferences, taught Introduction to Education and Diverse Populations courses at Miami-Dade College, and science methods courses for preservice elementary teachers at USF. She has accepted a Postdoctoral Research Associate position at the University of Miami.