Exploration of Differences in the Beliefs and Attitudes of Biology, Chemistry, Earth Science, and Physics Teachers on Multiculturalism in Secondary Science Classrooms

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Submitted in partial fulfillment of the
requirements for the degree of
Doctor of Philosophy
under the Executive Committee
of the Graduate School of Arts and Sciences

COLUMBIA UNIVERSITY

2020

Abstract

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This study explored if there are differing beliefs and attitudes regarding working with students of multicultural backgrounds based on the content area specialties (i.e. biology, chemistry, Earth science and physics) of in-service secondary science teachers. The study was mixed methods and conducted in two parts. The first part focused on the use of quantitative statistical analysis to review the results of 152 respondents to a 54 Likert questions on the Survey on Multiculturalism in the Science Classroom (SMSC). The statistical analysis was followed up with qualitative analysis of interviews with 12 in-service science teachers representing the different content areas. Quantitative findings indicated that biology and Earth science teachers demonstrated similar patterns of responses in terms of comparative statistical analysis, network correlation diagrams, and general responses to the Likert items from the SMSC. Of the four content area groups, physics teachers demonstrated the greatest difference in their responses regarding multiculturalism. The results also showed that the beliefs and attitudes of chemistry teachers were correlated with those of physics teachers; this was not the case for biology teachers and Earth science teachers. Themes emerging from a qualitative analysis of the interviews included the following: a) In-service teachers have received little formalized training in regard to working with multicultural students; and b) Differences in teacher beliefs and attitudes reported in this study could be the result of diminishing representation of students from multicultural backgrounds in the different sciences, particularly as students move through a traditional progression from biology, to Earth science, to chemistry, to physics.

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Acknowledgements

This journey has been a long, and at times winding, journey which could not and would not have been possible without the help and assistance of a great many people who have been encouraging me and guiding me along the way.

I would like to begin by acknowledging the guidance of the professors at Teachers College and Columbia University, beginning with my deepest appreciation to my advisor Dr. Felicia Mensah. She has been a critical guide in this process of learning who opened my eyes to the questions that we are often afraid to ask in regard to race and equity in education, and helped me to realize the deep connections that can come from confronting ideas and following a path of study that is personally and emotionally challenging. I would like to thank Dr. O Roger Anderson for his support, the considerable time he took with me to develop the instruments of my study, and guidance he gave in developing my skills in working with quantitative data. I would like to thank Dr. Chris Emdin for his encouragement and willingness to ask questions and promote discussions about what it means to bring cultural perspectives into science, Dr. Victoria Marsick and Dr. Ruben Gonzalez for making time to be part of the defense of this study, and Dr. Jessica Ricco, who tried to keep me organized and focused on the ultimate goal.

I would like to thank my many colleagues in science teaching and educational administration who helped shaped the experiences that have led me to make meaning out of my work in Teachers College and my journey in the field of science education. I would like to thank Dr. Daniel Carleton, who gave me my first opportunities after college and has always been a supporting voice and a cheerleader even when the road seemed daunting.

And a very special thank you goes out to my parents-- Samarendra and Tripti Biswas-- for the value they placed on education and for all the love and support they have given me. To

my sister Swagata, who has an uncanny ability to balance living in multiple cultures. To my wife, Jill, for her constant love, support, encouragement, and perseverance. And to my children, Nora and Jai, who have brought new meaning to my work and to my life.

-SCB

Dedication

This work is dedicated to the late Samarendra Biswas. A loving father and husband. An immigrant to America at the age of 18. You demonstrated what it meant to dream and to persevere. Your journey has been an inspiration. You are a role model who always worked hard to provide opportunities for your family and always placed a strong focus on the power and importance of education. Though unable to finish this part of my journey with me, I am happy that before you left, I was able to share that this path had been opened to me. I hope I can make you proud and see that all your struggles have been worthwhile. I keep you in my heart always.

Chapter 1: Introduction

1.1 Statement of the Problem

In 2002, science educators Lynn Bryan and Mary Atwater put a call out to the education community for the need for better understanding teachers' beliefs about multicultural issues, particularly in the field of science teaching and learning. Bryan and Atwater posited that a rapidly growing population of culturally diverse students would be underserved unless science teachers were more reflective of the critical role and attuned to equity for their students. Students needed to develop an understanding of how their beliefs shaped their actions. Bryan and Atwater strongly recommended that the role of science education is to "seize opportunities to use new knowledge of teacher beliefs to tailor instruction to address the conceptions of those who are expected to meet the needs of a variety of learners" (p. 825). As a school administrator working with secondary science teachers, my hope is that results of this study can assist me, other administrators, and all science educators in supporting both students of multicultural backgrounds and their teachers.

Today's science instruction can be viewed as having two major tasks. The first is to provide students with the tools and understandings necessary to make informed decisions about science and technology in their lives (Glaser & Linn, 1997; McLaughlin, Shepard & O'Day, 1995). The second is the preparation of the nation and its citizens for the ever-growing opportunities in Science, Technology, Engineering, and Mathematics (STEM) careers (Bybee, 2010). Underlying these two foci is the thread of "Science for All Americans," which posits that all students should show a proficiency in science understandings regardless of race, gender, or any other aspects of diversity (American Association for the Advancement of Science, 1989).

At a time when demographic data shows increasing diversity in urban and suburban school populations (Gollnick & Chinn, 2002), data from the 2009 and 2015 administrations of the National Assessment in Educational Performance (NAEP) in science show continued disparities when student scores are separated based on race, gender, special needs, and primary language (Condron, Tope, Steidl, & Freeman, 2013, National Center for Education Statistics 2009, 2011, 2015). Science educators have documented that in classrooms where there is a large representation of cultural diversity among students, instructors are faced with unique challenges in making the material accessible to all students (Brand, 2014; Lee & Buxton, 2010). Appendix D of the Next Generation Science Standards (NGSS), entitled "All Standards, All Students," emphasizes the need for science educators who are ready to accommodate the needs of` a diverse student body that is expected to have a solid grounding in scientific reasoning, scientific practice, and cross cutting scientific concepts (NGSS Lead States, 2013).

Traditionally, science at the secondary level has been taught as a progression of separate fields of science which assume increasing levels of complexity as students come closer to matriculating to college and careers (Vazquez, 2006). The material is generally taught with an emphasis on science and science literacy, with little or no emphasis placed on the cultural connections for an increasingly diverse student body (Lee & Fradd, 1998). An examination of the historical roots of the progression of secondary science coursework reveals that the most common progression of biology and Earth sciences, then chemistry, and finally physics originated from attempts by reformers at the turn of the 20th century to standardize the curriculum and develop common expectations and rigor for coursework with college bound students of the time in mind (DeBoer, 1991; Tyack 1974). The work at that time done by the Committee of Ten led to the specialization of teachers within the differing fields of science

(Ravitch, 2000; Vazquez, 2006) with what was perceived as increasing rigor based on a premise of increased mathematical modeling in upper level courses of chemistry and physics (Sheppard & Robbins, 2005). This structure, which still influences the science progression of today, was designed at a time when only members of the privileged, White upper and upper-middle class were expected to attend post-secondary schooling (Tyack & Cuban, 1995; Vázquez, 2006).

These traditional structures result in separating science teachers based on content specialties. Studies have shown that teachers of the different specialized disciplines of science often have differing beliefs that impact their roles as science educators. Teacher beliefs on the Nature of Science (Billeh & Hassan, 1975), and use of inquiry-based learning (Breslyn & McGinnis, 2012), have been shown to differ based on the content specialization of the teachers. If similar differences exist in teacher beliefs and attitudes about the inclusion of multicultural perspectives in the classroom, there also exists a possibility that many traditionally underserved populations may continue to face hurdles in obtaining a well-rounded preparation for both science literacy and STEM careers due to potential differences in the beliefs and attitudes of different science content area teachers.

Studies on the cultural sensitivity and cultural awareness of pre-service science teachers have shown that coursework and a focus on multiculturalism during the teacher's education does impact their beliefs and attitudes on the importance of addressing the needs of traditionally underrepresented students, as well as their awareness of the need for culturally responsive teaching (Bianchini, Cavazos, & Rivas, 2003; Bryan & Atwater, 2002; Mensah, 2009; Siwatu, 2011; Taylor & Sobel, 2001). At the time this study was initiated, there was a gap in the literature regarding beliefs and attitudes of in-service science teachers, thus a need for this research study.

1.2 Prior Investigations

An earlier study that I completed on diversity in science classes, which is described in more detail in the methodology section, indicated potential differences in the beliefs and attitudes of science teachers based on their areas of specialty. In that study, four science teachers (two biology teachers, one chemistry teacher, and one physics teacher) from the same suburban school district were interviewed about diversity in science education. During the study, both the physics teacher and chemistry teacher indicated that the cultural backgrounds of their students should not affect the student's success. Conversely, both biology teachers indicated that they did see minority students struggling in science and that they had to consider specific strategies to assist minority students in making connections that their White counterparts may not require.

1.3 Purpose of the Study

The purpose of this current study is to examine the beliefs and attitudes of in-service science teachers about multiculturalism in the classroom, determine if there are differences based on the content specialties of science teachers, and explore underlying phenomena that may contribute to any identified differences. The rationale for the study posits that a better understanding of teacher beliefs and attitudes can in turn improve the development of programs to better educate science teachers; particularly, in supporting science students with increasing cultural diversity and providing equitable access to science for all students.

1.4 Research Questions

The research questions guiding this study are:

1. How can we characterize differences in the beliefs and attitudes of in-service secondary science teachers of different content specialties (i.e., biology, chemistry, physics, and Earth science) in working with multicultural students in secondary science classroom settings?
2. What underlying factors attribute to the patterns of differences and similarities when comparing the beliefs and attitudes of secondary science teachers of different content specializations in regard to multiculturalism in the science classroom?
   a. How does teacher education and professional development influence beliefs and attitudes on working with students of multicultural backgrounds?
   b. Are there patterns in the representation of multiculturalism in different content area courses that attribute to differences in teacher beliefs and attitudes?
   c. How do the attitudes of teachers from different content area specialties influence the representation of multiculturalism in science courses?

1.5 Organization of the Dissertation

Chapter I of this dissertation provides an introduction and rationale for the study. Chapter II is a literature review, which includes the historical context for the division of science education along subject specialty areas (i.e., biology, chemistry, physics, and Earth sciences), policy reforms that address equity in science educations, current practices that include the needs of multicultural student backgrounds in the classroom setting, impacts of teacher beliefs on classroom instruction, and current trends in teacher education that focus on teacher beliefs and practices relating to multiculturalism in science classrooms. Chapter III describes the methods used in this research, including initial investigations, development of the survey tool, and both quantitative and qualitative methods of data collection and analysis. Chapter IV presents the findings from the quantitative analysis. Chapter V contains the findings from the qualitative analysis. Lastly, Chapter VI presents a discussion of the findings as well as implications and limitations of this study.

Chapter 2: Literature Review

In the following section, I review literature that addresses several issues related to the study of beliefs and attitudes on multiculturalism in the science classroom. I first examine the distinction between attitudes and beliefs, and then provide historical contexts for the traditional and widely accepted progression of science courses that has roots in educating a predominantly White middle to upper class population. This includes issues related to policy and reform movements that have attempted to address gaps in science achievement along racial and ethnic disparities. I elaborate on the current data on the progress of multicultural students in the science classroom and the spectrum of pedagogies that focus on classroom diversity. Finally, I conclude with an examination of literature on studies of pre-service science teacher beliefs and practices on multiculturalism. The goal of this study is to understand the beliefs of science teachers about multiculturalism and cultural diversity in the classroom, with a focus on how content specificity and experiences may impact those beliefs.

2.1 Distinguishing between Attitudes and Beliefs

This study examines teacher attitudes and beliefs, which represent subsets of constructs that describe the mental states that influence a teacher's instructional practices. As such, the attitudes and beliefs a teacher has impacts their understanding of knowledge acquisition and interpretation, defining and selecting instructional tasks, interpreting course content, and making choices in assessment (Jones & Carter, 2013; Keys & Bryan 2001; Richardson, 1996). The study distinguishes between beliefs and attitudes along the lines delineated by Fishbein (1967) in which beliefs are presented as internal cognitive constructs and attitudes that are affective constructs associated with a behavioral response. Researchers in the field of education have further expanded on the definition of beliefs as a personal construct based on personal judgements and evaluations (Luft et al, 2003) and "psychologically held understandings, premises, and propositions about the world that are held to be true" (Richardson, 1996, p.103). Consequently, the definition of attitude as used in this research can be stated as two related constructs: a) the behavioral "predisposition to respond positively or negatively to people, places, events, or ideas" (Simpson et al., 1994, p.212) and b) "how favorable or unfavorable an individual feels about performing a behavior" (Jaccard et al., 1999, p.103).

Where the definitions of attitude have a direct relationship to instructional behaviors, research has shown that disconnects can exist between teacher's stated beliefs and their actions. Justi and Gilbert (2002) found that teachers who have positive beliefs on using scientific models to develop student interest and promote conceptual change, do not widely report using models in their practice. Peacock and Gates (2000) found that although some teachers declare science materials should focus on the students' level of preparedness, some teacher decisions about textbooks and course materials were based primarily on the demands that the integration of the materials placed on them as teachers. Lotter (2004) found that pre-service teachers who expressed beliefs on the importance of inquiry and student ownership of the curriculum were more likely to focus on issues that were related to themselves over those expressed by students. Taylor and Sobel (2001) found that although pre-service teachers believed in the importance of developing instruction that could reach all learners in a multicultural setting, their planning rarely considered interactions with the culture and language of students they taught. With such disconnects in mind, it becomes important to more carefully examine the internal beliefs and behavioral attitudes expressed by teachers, especially across disciplinary domains.

2.2 The Committee of Ten and the Historical Context of the Traditional Secondary Science Progression

As the United States approached the 20th century, dramatic changes in the social structure of the country prompted a renewed focus on the education systems of the nation. An accompanying rapid increase in the population of high school students led to a national review of the state and goals of the high school curriculum by the National Education Association's (NEA) Committee of Ten, which would have lasting impacts on the state of education, and particularly that of the sciences, for over a hundred years to come.

Prior to the growth of high schools in the 1890's, secondary schooling was viewed as preparation of mental discipline necessary for college or the "real world" through the studies of reading, writing, arithmetic (the Three R's), and the classical curriculum focusing on Greek and Latin (Kliebard, 2004). Most of the population did not complete high school due to the economic cost of losing the wages of a potential household earner (Tyack, 1974). As a result, a complete secondary education and, consequently, a university education had become attainable by only a small elite segment of the population that could afford to send its children to school. The 1890's saw a doubling of the population due in part to the immigration of nearly 14 million people into the nation, a migration of the population from rural communities into cities, a transformation from a nation made up of many smaller, secluded communities into a nation of communities inter-connected through advances in communication and transportation, and changes in the employment practices resulting from revised child employment laws (Kleibard, 2004). All these factors, in concert with a focus from educational reformers to improve both the quality and access to education (Bohan, 2003), led to a drastic expansion of public school systems, great shifts in the numbers of students who continued their education beyond primary school, and the existence of nearly 6,000 high schools across the nation (Davidson, Stoff, & Viola, 2000). As the shifts in society created growing demands for commercial and industrial education, these were accompanied by a proliferation of applied and vocational course offerings that expanded the diversity of classes taught at the secondary level (DeBoer, 1991; Tyack, 1974). The growing numbers of secondary schools and the large variation in the curricular offerings resulted in a growing concern for the standardization of college entrance requirements and a discussion at the national level about the standardization of the high school curriculum, leading to the establishment of the NEA's Committee of Ten in 1892.

The Committee of Ten, chaired by Charles Eliot, was tasked with surveying the coursework that was being offered throughout high schools and to determine the breadth of curriculum that universities should expect high schools to have taught to college-bound students. Charles Eliot, president of Harvard University, and a notable figure in the humanist movement in educational reform, saw the main purpose of schooling to be the development of reasoning power beyond the three R's, and believed students needed to expand their abilities to observe, record, and analyze data in order to make inferences, as well as properly express their ideas (DeBoer, 1991; Kleibard, 2004; Ravitch 2000). Eliot, and proponents of the Humanist Movement, argued that it was the duty of schools to provide a liberal education, appropriate for all students; and there should be no distinction between those preparing for college and those preparing for life (Kleibard, 2004).

In all, the committee was composed of three high school principals, six university presidents or faculty members, and the Commissioner of Education. The committee in turn created nine subcommittees, or conferences, each made up of experts within the fields of Latin, Greek, mathematics, English literature, modern languages, history, natural sciences (physiology, zoology, botany), physical sciences (physics, chemistry, astronomy), and geographic sciences (geography, geology, meteorology). All these conferences were tasked with answering the same set of questions: What topics should be studied in high school? How much curricular time should be allocated to each subject? How should each subject be taught and assessed? What were the best methods for teaching subjects? And should the subjects be arranged differently for college-bound students? The conferences reported their findings and recommendations back to the Committee of Ten, who in turn synthesized the multiple reports into one set of recommendations to report out to the NEA and the public (Sheppard & Robbins, 2007).

The Conferences on Science

It is particularly important to note that Eliot had been a strong proponent of incorporating the use of laboratory activities in the learning of science (DeBoer, 2000). He had organized the conferences to include three separate groups to represent the disciplines of science. Up to this point, much of the collegiate expectations for high school students who would move on to university life had focused on the classical subjects of mathematics, Latin, and Greek; which were seen as the subjects that had traditionally served to train the mental discipline of the student through repetition and memorization. There was in fact a great deal of discussion on whether to include the modern subjects of English literature, modern language, history, natural (life) sciences, physical sciences, and geographic sciences. The sciences in particular had been of great debate because they were seen to have a more humanist and progressive view of education due to the focus they placed on making inferences based on observations, in lieu of the traditional approaches of rote memorization that had been popular in educational practice (DeBoer, 1991). The recommendations of the three conferences focusing on science would not only lead to the eventual situation of science as a part of the academic canon, but also impact the curricular practices of science to this day. All three conferences touted the need to develop laboratory components of the courses that would directly address the development of mental processes. In addition, the conference on physical sciences recommended that the teaching of chemistry and physics should be required for college admission. Basic physical sciences should be taught in the elementary grades, but a more rigorous physics course be taught after chemistry and after students had developed the mathematical skills that would allow appreciation of the quantitative nature of the science The conference on natural sciences recommended that elementary science courses should not put too much emphasis on anatomy. At the high school level, because botany and zoology were viewed as more descriptive than experimental, the coursework should be more focused on the student's mental discipline and intellectual growth; aspects that were related to observation, rather than the acquisition of content knowledge. The conference on geographic sciences recommended that students at early grades be exposed to a broad study of the features of the Earth early on; and at the high school level, the coursework should focus on both direct observations and on the descriptions reported by others (including textbooks). The main purpose should be to observe changes and processes and to develop an understanding of the development of the Earth's features instead of focusing on memorization of content (DeBoer, 1991).

In terms of science, the final report of the Committee of Ten included the recommendation that students complete a minimum of one year of science, that chemistry and physics be taught during the final two years of the curriculum, that sciences have a significant lab component, and that the primary focus for instruction be on acquiring knowledge and growth through observation and experience instead of through rote memorization. The recommendation to incorporate science, along with curriculum for modern foreign language, social studies, and

English literature, was intended to put modern subjects on par with the classical subjects and create a liberal education curricular framework that would be appropriate for all students.

Over the course of the following decade, the report from the Committee of Ten resulted in colleges accepting studies of the sciences and other modern subjects as sufficient preparation for college admission. Consequently, enrollments in high school science courses grew exponentially, more teachers became specialized within specific disciplines, and there was increasing alignment of many state, district, and school curricula to the committee's recommendations (Ravitch, 2000, Vazquez, 2006).

After the turn of the 20th century, the Humanist ideology of the Committee of Ten fell into disfavor. Critics called for more differentiation in curricula as well as for the development of vocational training programs. Claims abounded that that the Committee of Ten's curriculum both weakened the mental training of those entering college while perpetuating a system of elitism. The rise of the Developmentalist and the Social Efficiency Movements of educational reform – both of which made arguments for differentiated curriculum, though for completely different reasons – resulted in the abandonment of the Committee of Ten's liberal-arts-centered curricular model.

Impact of the Committee of Ten on Science Education Today

Even as the Humanist ideology, the Developmentalist ideology, and the Social Efficiency model have all entered and exited as the principles underlying educational policy, the impact of the Committee of Ten can still be seen in science curricula today. Science has remained a part of the core disciplines that all high school students must study. Laboratory work continues to be a mainstay of most science curricula. The delineations that were made by separating science into three separate commissions continue to influence how new branches of science are categorized, with most high schools continuing to offer courses grouped into sub-disciplines of biology, chemistry, physics, and Earth sciences. In most high school curricula of today, topics within botany, zoology, and physiology have been incorporated into biology. The study of biology is still most commonly the first science that most students experience at the secondary level. Chemistry and physics generally follow sequentially in order to allow students to develop mathematical and reasoning skills that have been associated with the subjects, and are considered to be the more challenging disciplines within the sciences (Sheppard & Robbins, 2005, 2007; Vasquez, 2006).

The restructuring of the school curriculum, and science curriculum specifically, at the turn of the 20th century had at its essence a philosophy that the duty of schools was to provide a liberal educational basis for all students and there should be no distinction between those preparing for college and those preparing for careers. However, this inclusive focus did not take into account the increasing number of immigrants entering the nation and shifts in schooling and the science curriculum that made many different demands. There was inadequate attention to the difficulties, needs, and perspectives of the increasing diversity of students in secondary education. Nearly a century would pass before inequities in the achievement of students along categories of gender, race, ethnicity, and ability would lead to a national conversation on what "Science for All" truly means; and also where understandings of diversity fit into national science education policies.

Differences among the Disciplines of the Sciences

The impacts of the Committee of Ten on the division of science into different sub-disciplines allowed for teachers of the content areas to become more focused on, and knowledgeable about, the specifics of their fields of study. This continued specialization in the sciences at the secondary level can be seen by reviewing the certification and licensure procedures that teachers must undergo to become professionals. Though there is a certification process through the National Board for Professional Teaching standards, education in the United States falls under the jurisdiction of the state governments. There are no federally recognized teaching licenses that are accepted in all educational institutions in the nation. However, visiting the websites of multiple state departments of education do show commonalities among states in their requirements to become a recognized teacher and the certifications that teachers can receive. For example, a brief search through the websites of the New York State Education Department, Minnesota Department of Education, Connecticut State Department of Education, California Department of Education, Ohio Department of Education, Texas Education Agency, and Colorado Department of Education shows that the states require separate certifications to teach biology, chemistry physics, and Earth (or geo) science at the secondary level.

Recent work in the field of instructional technology (Howard, Chan, & Caputi, 2015) demonstrated that there are correlations between subject area of teachers and their views on the use of technology and the willingness to integrate pedagogical strategies around technology into practice. In a study examining the views of scientists on the Nature of Science (NOS) and the role of inquiry, Schwartz and Lederman (2008) indicated that the teachers' overall views of NOS were similar, yet with subtle disciplinary differences based on the field of science. Physicists in the study were found to be "most notably distinct" in their views (p. 762). Chemists and life scientists in the study tended to be more experimental in their investigative approach. The researchers speculated that these differences may be related to discipline or investigative approach.

Breslyn and McGinnis (2012) investigated the implementation of inquiry-based learning strategies relating to subject area of the science teacher. The study found that biology and Earth science teachers were more likely to focus on development of scientific inquiry skills, chemistry teachers were more likely to focus on content learning, and physics teachers were more likely to approach modeling of phenomena in their instruction. The authors commented on the critical importance of taking the discipline of a science teacher into consideration in understanding the varied conceptions and considerations that exist regarding the use of inquiry.

If similar differences are present in teachers' beliefs regarding working with students of multicultural backgrounds in a science discipline, there exists a possibility that many traditionally underserved populations may continue to face hurdles in gaining a well-rounded preparation for both science literacy and STEM careers. This may be due to teachers in the different fields of science being more likely, or not so likely, to acknowledge and adapt to cultural differences among their students. As stated previously, and emphasized here, this is the area of inquiry of my current study.

2.3 Diversity in Science Standards: From "Science for All" to the Next Generation Science Standards

In 1989 the American Association for the Advancement of Science (AAAS) released "Science for All Americans," a report that called for reforms in the science curriculum. The report was a response to the then growing concern about the "cascade of recent studies [that have] made it abundantly clear that by both national standards and international norms, US education is failing to adequately educate too many students -and hence failing the nation" (The Psychologist, 1989, p. 245). A prime focus of the report was on encouraging scientific literacy, which the National Research Council defines as “the knowledge and understanding of scientific concepts and processes required for personal decision making, participation in civic and cultural affairs, and economic productivity” (1996, p. 22). In its final chapter, reflecting on the next steps to be taken, the report suggests that “US schools have yet to act decisively enough in preparing young people especially minority children, on whom the future of America is coming to depend - for a world shaped by science and technology” (p. 227). The phrase of “Science for All Americans” has remained a central theme of science reform movements since its release.

“Science for All Americans” was followed by all states developing standards-based reforms in science focusing on scientific literacy and the nature of scientific investigations with the goal of achieving high academic standards for all students (McLaughlin, Shepard, & O'Day, 1995). By 1996, the National Research council had developed a set of National Science Educational Standards (National Research Council, 1996) to use as guidelines for development of state standards and all 50 states had developed new standards for science, along with standards for the core subjects of mathematics, social studies, and English Language Arts (Council of Great City Schools, 1996; Lee & Fradd, 1998; McDonnell, McLaughlin, & Morrison, 1997). New standards in science placed emphasis on the understanding of key concepts and relationships, higher-order thinking, inquiry-based learning, communication of ideas, application of information and developing habits of mind in lieu of the then-traditional memorization and reporting of rote information (Glaser & Linn, 1997; McLaughlin, Nolet, Rhim, & Henderson, 1999; McLaughlin et al., 1995). However, there was little emphasis placed on the additional supports necessary to ensure success of students from minority and underserved backgrounds; and the growing assessment that existing gaps in student understanding and performance along cultural lines would continue to grow (Lee & Fradd, 1998).

2.4 The National Science Education Standards

Critics of the National Science Educational Standards describe it as “a political document” with a weakness in its equity considerations (Lee 1999; Rodriguez 1997) stemming from an underlying discourse of invisibility and “not directly addressing the ethnic, socioeconomic, gender, and theoretical issues which afflict science education” (Rodriguez, 1997 p. 19). There are no specific references to a single ethnic group throughout the document; and it avoids addressing why equity is such a priority, or how it should be addressed. Noddings (1997) asserts that the preoccupation with creating national standards (and the ensuing development of state standards) diverts attention away from social issues that breed inequalities, prohibiting “Science for All” and instilling an erroneous belief that *all* students have an equal chance at success.

The key factor contributing to a false sense of “Science for All” stems from the definitions of science inherent in both the AAAS report and the National Science Educational Standards. Critics contend that the very definition of science used in the report reflects inherent values of traditional Western science, which echo a narrowness of perspective with prevailing images of science as something conducted in research laboratories by men in white coats following a specific scientific methodology – a perspective which typically privileges White males, at the expense of others (Harding, 1998; Lee & Buxton, 2010; McGinn & Roth, 1999). The documents promote the assimilation perspective suggesting that “individuals from diverse backgrounds adopt the mainstream culture while ignoring or rejecting their cultural backgrounds” (Lee, 1999 p. 92).

The creation of the documents that formed the basis of reforms in science education stemmed from a societal mindset that focused on developing high standards for the curriculum, instruction, and assessment of material with little consideration or support for students who did not come from backgrounds sharing the same Western Modern Science values (Quigley, 2009), which “further victimize students already harmed by gross inequalities in the educational system” (McLaughlin et al. 1995, p. 68). Furthermore, the strong focus on the accomplishments and contributions of Whites and Europeans and absence of Black and minority scientists in the historical development of major scientific understandings of what is considered the traditional science curriculum adds to the perception that science values White and Eurocentric perspectives over those of non-Western cultures (Johnson, 1993). As such, all too often, the current science curriculum sends a message to students of color that their ancestors contributed little to the foundations of sciences and that their own accomplishments are just as likely to go unrecognized (Leonardo & Grubb, 2013).

2.5 The Next Generation Science Standards (NGSS)

The Next Generation Science Standards (NGSS), released in 2013, represents the development of a set national standards for science, which are “rich in content and practice, arranged in a coherent manner across disciplines and grades to provide all students an internationally benchmarked science education” (Achieve, 2013). The standards were developed from the National Research Committee’s Framework for K-12 Science Education (NRC, 2012) and contained sections on equity and diversity (Appendix D, “All Standards, All Students”), with the seven case studies to specifically address the needs of student populations that have been traditionally underserved in science classrooms. Lee, Miller, and Januszyk (2014) describe the contributions made by the NGSS Diversity and Equity Team to reviewing the proposed standards. Their review looked specifically to avoid stereotypes and avoid unnecessarily difficult language. In order to assure that “all students be provided equitable opportunities to engage with scientific practices and construct meaning in science classrooms” (Lee et al., 2014, p. 225), the authors had input on how poverty, race and ethnicity, special education needs, English language learner needs, alternative education, and needs of gifted and talented students were addressed throughout the document. However Rodriguez (2015), while recognizing the NGSS places new visibility on issues of equity, critiques the document for not recognizing the impacts previous reforms have had on the practices of science teachers, the resistance teachers will have to the ideological and pedagogical changes in reforms around equity, and the lack of representation of multicultural perspectives among those who drafted the main body of the document.

The NGSS represents a large shift in the study of science and the incorporation diversity and equity in science education. Moving towards the principles of the NGSS will call for significant teacher professional development programs and research focused on the transitioning of science teachers (who are more familiar with pedagogy and practices that align with the values of Western Modern Science) towards becoming more culturally responsive to the perceptions and understandings that students from more culturally or linguistically diverse backgrounds bring to the classroom. Beginning with the acknowledgement of inequities in education during the period of the Civil Rights movement through today, it has been understood that addressing the strengths and needs of a diverse student body within national and state science standards and policies is a vital part of developing education that incorporates the ideas of “Science for All” (Atwater, 1994; Brand, 2014; Goodlad, 1990; Lee et al., 2014; Smith, 1969).

The Delay between Policy and Practice

Changes in educational policy take time as they "move through the separate stages of implementation talk, policy action, and actual implementation" (Tyack & Cuban, 1995, p.54). As such it becomes important to understand the beliefs of in-service educators on issues such as the inclusion of addressing equity and diversity in the context of science education, as it is the teachers who ultimately control the extent to which any reforms in education will take hold (Darling-Hammond, 1997; Elmore, 2003; Hatch, 1998). Further complications may also arise. Among these are the delay in penetration of possible changes in policy to the level of practice due to the institutional trends of "time lag between advocacy and implementation; uneven penetration of reforms in different sectors of public education; and the different impact of reforms on various social groups" (Tyack & Cuban, 1995, p.55). Practicing educators can become cynical of reform and changes in policy that may cycle and recycle "within the lifetime of the individual, sometimes at a dizzying pace" (p. 41), resulting in feigned implementation of reform while holding on to traditional practices and waiting for the eventual shift back. Studies have shown that professional development on reforms disseminated through top-down means are often short-lived, as teachers feel it can be "taken or left" without much impact on their practices (Darling-Hammond & McLaughlin, 1995; Darling-Hammond, Wei, Andree, Richardson, & Orphanos, 2009; Kaestle, 1993; Wineberg & Grossman, 1998). This may particularly happen when the reforms do not align to their beliefs and attitudes.

2.6 The Changing Face of the Nation and Student Alienation in Science

Over the course of the past several decades, the demographics of the nation's urban and suburban centers have undergone rapid and significant shifts leading to a greater diversity in the student body and an increase in the numbers of students that have been traditionally considered to come from minority or underserved backgrounds (Frey, 2011; Sutter 2011). According to the National Center for Educational Statistics (NCES, 2011), approximately 36% of public school students are classified as students of color. In 2011, the birth of minority babies outnumbered the birth of White babies, signaling a transition of the United States from the predominantly White and European majority that dominated the culture of the nation from its founding through the later part of the 20th century, into to a more globalized and multi-racial nation (Frey, 2014). Based on current projections, by 2050 the population of children of "minority" backgrounds is expected to be 62% (Bernstein, 2008). These changes in the demographic makeup of the nation makes it increasingly important for educators to understand needs of a culturally diverse student body and the pedagogical practices that best help support them (Thomson, Wilder, & Atwater, 2001).

Data collected from the 1996 National Assessment of Educational Progress (NAEP) show that only 4% of Black students were found to be proficient in science as compared to 24% of White students. Furthermore, White students outperformed their Black and Hispanic peers in science in all age categories. Data from the 2009 NAEP in science shows continued disparities in science when student scores are separated based on race, gender, special needs, and primary language (College Board, 1999; Condron, Tope, Steidl, & Freeman, 2013). A 2009 NCES study of high school transcripts showed an increase in the enrollment of students in higher level science classes; however, 52% of Black students and 50% of Hispanic students were likely to be missing the science components necessary to qualify for standard level diplomas or above, in comparison to 25% of White students (Nord, Roey, Perkins, Lyons, Lemanski, Brown, & Schuknecht, 2011). This data on the performance of students in secondary education correlates with National Science Foundation (2017) data reporting that, as of 2014 although Blacks, Hispanics, and Native Americans make up 32% of the total labor force in the United States of America, they make up only 13% of the science, mathematics, engineering, and technology work force.

As educational researchers have begun to explore the field of discrepancies in outcome measures for minority and underserved populations in comparison to those of the White majority, issues of alienation and cultural marginalization are often seen as one of the root factors influencing the achievement of students who come from culturally or linguistically diverse settings (Brand, 2014; Brand, Glasson, & Green, 2006). For many traditionally underserved or marginalized youth, this sense of alienation and marginalization in the sciences stems from the feelings of being the "other" and a need for a sense of belonging that can be traced back to ways in which teachers fail to incorporate meaningful cultural connections within the curricula for the diverse students they teach; thus, resulting in a loss of motivation to persist in the sciences (Aikenhead, 2001; Emdin, 2010; Hurtado et al., 2007; Nadeau & Desautels, 1984; Seymour & Hewitt, 1997). The resulting difficulties and disconnection that students display can lead to a compounding of the teacher's perception of students being disinterested in science and the eventual actual disinterest in the subject (Emdin, 2010). This resulting marginalization may derive from the limited access to materials and encouragement needed for engaging in science, or the lack of understanding displayed by teachers of the behavioral and linguistic patterns, values, or viewpoints of the students home culture (Brand, 2014; Norman, Ault, Bentz, & Meskimen. 2001). Culturally relevant pedagogy addresses shifts in pedagogical practices that can support traditionally underserved students who may differ from ideologies and culture of the White, upper and middle-class male students that have been both the designer and beneficiary of the traditional structures of Western Modern Science (Quigley, 2009; Tyack & Cuban, 1995). This historically rooted hierarchy in society, and in the design of its academic structures, has fostered a culture that promotes strict adherence to regulations that undermine the needs and dispositions of student populations that do not conform to those traditionally associated with White middle-class male students.

Based on the demographic shifts outlined above, a greater proportion of students today, and even greater numbers of students in the future, will represent diversity in terms of their cultural backgrounds, linguistic backgrounds, and ability levels (Gollnick & Chinn, 2002). Their differences will include factors such place of residence, family occupation, income, race, gender, and mental or physical handicaps (Tyack & Cuban, 1995). These students will continue to feel disconnected to schools and their science classrooms, if educational curriculum practices continue to follow the traditional curriculum banding aligned with the modes and understandings of the predominantly White middle and upper class population, stemming from the Committee of Ten's design for standardized secondary curriculum tracing back to the turn of the 20th Century (DeBoer, 1991; Kleibard, 2004; Ravitch 2000; Tyack, 1974).

2.7 Multiculturalism and Multicultural Philosophies

Esteban-Guitart and Moll (2014) suggest that the identity of a student develops from the funds of knowledge that are available in the home and community through complex interactions of cultural beliefs and practices, social experiences, and historic contexts which surround the student. Allen & Boykin (1992) found that for many students, especially for those coming from traditionally underserved or culturally different populations, the behaviors and discourses deemed necessary for success in school contrast with the cultural and linguistic practices of the students' homes. This lack of congruence between the school life and the home life of students can lead to a teacher's perception of students being disinterested in science and eventual actual disinterest in the subject stemming from feelings of alienation and marginalization (Emdin, 2010). This marginalization may derive from the limited access to materials and encouragement needed for engaging in science, as well as a lack of understanding of behavioral and linguistic patterns, values, or viewpoints of the dominant culture (Brand, 2014; Norman, Ault, Bentz, & Meskimen. 2001). The resulting disconnect can reinforce perceptions of disinterest as opposed to the actual disconnect that the students have with the pedagogy through which the content is presented (Norman et al., 2001). These perceptions of disinterest are compounded when the students are not treated by teachers as full participants in science, or when students do not perceive themselves as being successful in science, resulting in alienation that in turn perpetuates the existing gaps between the culture of school and that of the students (Emdin, 2010).

The existing gaps in performance between traditionally underserved populations struggling in science is further exacerbated by the general lack of understanding of schools, teachers, administrators, and policy makers to account for the needs of the students. As Richard Elmore (2003) wrote:

> As a matter of practice, we know very little about how to accelerate learning in specific domains from students whose performance is well below that of their peers. Most so-called remediation consists of putting students in the same kind of instructional settings in which they failed in the first place for longer periods of time, on the theory that it was the students who failed rather than the teachers who taught them. As the variability in student performance becomes clearer, the paucity of effective remediation and

> acceleration practices will become clearer, as will the relative lack of knowledge base in this area and an institutional infrastructure to bring it into schools and classrooms. (p.46)

The ultimate goal for educators who foresee a future equitable for all students is to focus on a variety of enhancing emphases; including, but not limited to: a) multiculturalism, diversity, and equity education in the sciences, b) understanding the needs of a multicultural population, c) developing opportunities for the success of all students, d) eliminating the alienation of sub-populations, and e) eventually bridging the differences in student outcomes along cultural, racial, gender, or any other dividing lines. However, an educator's beliefs on what it means to be equitable can vary drastically based on their perceptions of what it means to teach in a multicultural setting and even the very goals of equity in education.

2.8 Philosophies of Multicultural Education

According to Christine Sleeter (2018), the term *multicultural education* was first introduced into the educational discourse in 1973 through the report entitled *No One Model American: A Statement on Multicultural Education* put forth by the American Association of Colleges of Teacher Education. The multicultural education movement sprang from the American Civil Rights movement of the 1960's and 1970's in an attempt to ensure non-discrimination and advocate for the inclusion of practices and expectations to address the needs of students who had been marginalized in a system of education, and at its core, multicultural education was designed nearly a century earlier with the needs of White middle and upper class males in mind (Kimlycka, 2013; Sleeter, 2018; Tyack & Cuban, 1995). The movement began in the context of multi-ethnic education which focused on the needs of Black Americans, Puerto Ricans, Mexican Americans, Asian Americans, and Native Americans, and expanded to include the needs of other marginalized groups, such as women and people with disabilities (Banks 1996, Sleeter 2018). Sleeter (2018) contends that multicultural education transcends strategies and curriculum content to include “the struggle for the power to define he purposes and processes of education in a diverse and unequal world” (p. 6).

A review of the literature on multicultural education has revealed a range of differing goals and interests that color the spectrum of multicultural education. As Hodson (1999) points out, the philosophies of *multicultural science education* are divided by the disparaging goals of the field itself. In his call for use of science education as a means of sociopolitical action, Hodson identifies the competing goals of assimilation and pluralism.

Multiculturalism with the goal of *assimilation* contends that students from culturally different backgrounds should learn to match the norms, perspectives, and outcomes of the dominant culture to more easily function within the context of the dominant culture. In assimilation, the differences and alienation of students along racial or linguistic lines are recognized but fitting into the dominant culture is viewed as the ultimate goal. The cultural traits that students hold, that are not aligned with the culture of the dominant group, are viewed as deficits to be overcome. Students are thus encouraged to give up their racial or ethnic identities to conform to the dominant culture (Hodson, 1999).

In the goal of *pluralism*, the prevailing ethos is that the dominant culture can learn to appreciate the differing norms and perspectives across cultures (Hodson, 1999), and in so doing be socially enriched and likely more successful. Pluralism goes beyond surface acknowledgement of multiculturalism to incorporating the contributions or alternative views of other cultures into the curriculum in order to make students who identify with the dominant culture more aware of the beliefs of other cultures. Although Hodson identifies pluralism as the ultimate goal of multicultural science education, he recognizes that the dominant groups' pre-existing position of power may lead it to "unwillingly continue to oppress those of other backgrounds by promoting policies and practices that serve their best needs while only making passing reference to the interests, needs, aspirations, and values of other communities" (p.777). In either case, individuals who do not agree with, or aspire to, the attitudes and beliefs of the dominant culture are frequently labeled as militants, agitators, or extremists, which further emphasize that their beliefs are outside the "normal" beliefs. Thus the beliefs of the dominant culture are seen as the status quo and these "status characteristics that are allowed to operate unchecked can actually reinforce cultural prejudices and asserts that cooperative group interactions offer a mere chance to attack these prejudices" (Ferris, 2012, p. 40).

2.9 Spectrum of Multicultural Pedagogies

There is a wide spectrum of beliefs and practices that are implemented when confronting multiculturalism in the science classroom. Some of the challenges range from teachers not acknowledging the presence of diversity to encouraging more promising approaches of implementing a curriculum based around social justice and societal transformation.

To not acknowledge diversity as part of science education represents one extreme on the above continuum. Such a belief sees science as a truly objective field based on the use of a traditional disaffected and value-free scientific method in which science content focuses on objective absolute truths (Nadeau & Desautels, 1984). Such a perspective assumes that all students are subject to making the same observations and attributions regardless of differences in cultural or linguistic backgrounds. In such a context, the cultural differences between students' native cultures and the culture of the science classroom are non-existent in the eyes of the teacher.

Along the same lines, the processing of science content would be expected to be the same among students of all cultural backgrounds. Leonardo and Grubb (2014) describe this unsatisfactory state as a post racial setting, in which the teacher does not address differences along ethnic or racial lines because of a belief that race and discrimination no longer impact educational, or societal, constructs. In such a traditional Western Modern Science model of education, the "hidden curriculum" promotes the beliefs and norms of the dominant culture, affirms stereotypes, social norms, and cultural roles, and contributes to the alienation of those not viewed as part of the dominant group (Anyon, 1981; Apple, 1986).

Acknowledgement of diversity in the classroom, and a realization that students of different backgrounds have different experiences and different levels of connection with the content should represent the next step in the gradient along the spectrum of multicultural teaching. Teachers with a sociocultural awareness may not address differences between students due to a lack of the skills necessary to acknowledge differences, may not attribute the differences in performance to differences along racial or ethnic lines, or address multiculturalism at the surface without acknowledging the cultural distinctions between groups (Brand, 2014). Such surface acknowledgements may include referencing of contributors who have similar cultural or linguistic backgrounds to students or addressing customs or traditions of other cultures in passing (Mensah et al., 2018). However, such practices may purposefully single out specific students or groups of students, who in turn may be marginalized for being identified as deviant or inferior (Ferguson, Gever, Minh-ha, & West, 1990). King (1992, 2015) uses the term *dysconscious racism* to describe the action of seeing that racial differences exist but accepting inequities as a given condition. Though dysconscious racism does not constitute a purposeful intention to deprive, harm, or punish students on the basis of their race or ethnicity, the underlying awareness of how some children are privileged in the classroom, while others are disadvantaged, also leads to marginalization, alienation, and even reaffirmation of some students being superior to others as an effect of membership in the socially dominant culture.

2.10 Culturally-Based Teaching

With the increasing importance of STEM education and career readiness for both individual and national growth, there is a need to address teacher capacity and preparedness for teaching students that come from culturally diverse backgrounds and prepare these students to take on roles as scientists and engineers that, previously, they may have been unprepared for or largely denied (Villegas & Lucas, 2002; Walls, 2014). Failure to do so will eventually "lead to the nation falling further and further behind other developed and developing nations in the world" (Walls, 2014, p. 56).

Culturally Responsive Teaching

The growing field of research and practice in culturally responsive teaching seeks to understand the needs of culturally and linguistically diverse learners and develop strategies that teachers can implement to make meaningful connections for these students with the science content and skills. Gay (2000) defines culturally responsive teaching as using the cultural knowledge, prior experiences, and performance styles of diverse and historically marginalized students to make their learning more appropriate and effective. Culturally responsive teaching looks to address the alienation of students through the development of channels that bridge the perceived differences between the home cultures of the students and the culture of schools by making adjustments in curriculum and pedagogy to make instruction learner-centered and highlighting the perspectives that different students bring to the content (Allen & Boykin 1992; Heath 1983; Ladson-Billings 1994). Lee and Lukyx (2006) assert that:

> All students come to school with knowledge constructed within their home and community environments, including their home language as well as their cultural beliefs and practices. Learning is enhanced – indeed made possible – when it occurs in contexts that are culturally, linguistically, and cognitively meaningful and relevant to students. Effective science instruction must consider students' home cultures and languages in relation to the pedagogical aims of science instruction. (p. 72)

The National Center for Culturally Responsive Educational Systems (NCCREST) sees three principal components of culturally responsive teaching as *instructional*, *institutional*, and *personal*. The instructional component is comprised of the materials, activities, and strategies used by culturally responsive teachers. The institutional component is comprised of the organization, resources, policies, and values of the school and the school administration. The personal component is comprised of the values and perceptions of the individual teachers and the emotional and intellectual processes teachers must engage in to be responsive (Richards, Brown, & Forde, 2007).

Culturally Responsive Teaching for Teacher Education

Focusing on the teacher aspect of cultural responsiveness and the preparation of pre-service teachers, Villegas and Lucas (2002) have outlined six characteristics of a culturally responsive teacher. The teacher

> (1) is socio-culturally conscious and recognizes that there are multiple ways of perceiving reality that are influenced by one's location in the social order;

(2) has affirming views of students from diverse backgrounds and sees all students as having strengths to contribute to the learning process rather than viewing differences as deficits that need to be overcome;

(3) sees himself or herself as both responsible for and capable of bringing about educational change that will make schools more responsive to all students;

(4) understands how learners construct knowledge and promotes learners' knowledge construction;

(5) knows about the lives of his or her students; and

(6) uses his or her knowledge about students' lives to design instruction that builds on what they already know while stretching them beyond the familiar.

Different aspects of cultural responsiveness include border crossing (Aikenhead,2001; Hand & Prain, 2006); reality pedagogy (Emdin, 2008; Powell, 1997); the use of third spaces (Gutiérrez, 2002; Moje, Ciechanowski, Kramer, Ellis, Carrillo, & Collazo, 2004); and studying the language of science in the classroom (Brown & Spang, 2008; Hand & Prain, 2006; Lee & Fradd,1998; Moore, 2007; Seiler & Abraham, 2009).

Social Justice Pedagogy

Moving beyond multiculturalism and pluralism, social justice and sociopolitical action pedagogies represent the use of pedagogy and curricula designed to critique issues that limit equity while developing instruction designed to empower marginalized communities. Educators with a focus on social justice look to achieve equitable education for all students by redressing the inequitable allocations of resources that allow the "privileged" dominant culture to continue to build upon the capital they already have, while limiting the access of those who come from underserved or marginalized settings (Brand, 2014; Chubbuck, 2010). Social justice pedagogy focuses on the barriers to learning encountered by students in underserved or marginalized communities, and challenges us to understand that alienation and marginalization of students is rooted in the messages of subordination and inferiority that come with labels of being at a deficit in comparison to the dominant culture (Brand, 2014; Giroux 1992). Sharing the characteristics of what Giroux termed as critical multiculturalism, social justice pedagogy calls on teachers to develop instruction and planning that goes beyond the content and beyond identifying the differences in learning and performance along racial lines, to understanding the institutional and societal practices that create such differences, and ultimately design strategies for motivating and supporting traditionally alienated and marginalized students (Chabbuck, 2010; Giroux, 1992).

A natural parallel for social justice for students lies in the research on the engagement of girls in the sciences (Walls, 2014). Halpern, Aronson, Reimer, Simpkins, Star, and Wentzel's (2007) recommendations for girls can be expanded to other underserved populations. These recommendations include four remedies: (1) reinforcing the idea that anyone is capable of learning and developing scientific concepts regardless of gender or race, (2) providing specific and actionable feedback on the tasks that students undertake rather than making general suggestions, (3) exposing students to role models of similar backgrounds who are successful in STEM related fields, and (4) providing a classroom environment that exposes students to opportunities to work with scientific tools and work on meaningful scientific research.

Similar to social justice pedagogy, Hodson's (1999) sociopolitical action pedagogy endeavors to develop curricula "that educates, enlightens, and changes both attitudes and behavior, and sows the seeds for the reshaping of contemporary society and its underlying values" (p. 777). Such a curriculum would utilize science teaching for defining problems within the community, with the participation of underserved populations of the community participating in research that has the potential to benefit the members of the community that results in socially relevant improvements (Hodson, 1999). Moreover, it should strengthen an awareness that anyone can have a positive impact on their own lives. Multicultural education with a goal of sociopolitical change would thus move beyond acknowledging diversity of the classroom, or the development of strategies to include traditionally alienated students, to a curriculum that proposes activism to empower students to make changes in their community.

Hodson (1999) takes a social constructivist view and builds on the work of Elliot (1994) and Sleeter (1996) in building communities with shared agency through (1) building a constituent base with common identity; (2) identifying and characterizing the strengths and weaknesses of the dominant culture; (3) enlisting, developing, and educating activists; and (4) developing a community awareness to develop a sense of urgency. Hodson's approach calls for teachers and students to take action on issues of importance in their community by following a process in which they:

(1) Define a problem to be studied that originates in the community and is defined, analyzed, and solved by the community.

(2) Establish ultimate goals of the research that will lead to radical transformation and improvement of the community.

(3) Involve the full and active participation of the community at all stages, with shared control of community members

(4) Conduct participatory research involving a wide range of exploited, oppressed, marginalized, and powerless groups: immigrants, refugees, labor groups, indigenous peoples, and women.

(5) Empower self-reliance and the awareness in participants of their own abilities and resources for organizing and galvanizing the community, rather than relying on outside assistance.
(6) Provide specialized knowledge and training necessary to support political and social advocacy.

Socio-transformative Constructivism

Like the pedagogies of social justice and sociopolitical action, a socio-transformative constructivist approach (Rodriguez, 1998, 2015) combines aspects of social justice theory with the learning theory of social constructivism to promote pedagogy that focusses on four areas:

(1) Dialogic conversation, in which students engage in verbal exchanges in with the goal of understanding what is being literally stated as well as the emotional, ideological, and conceptual reasons for the language the speaker chooses.
(2) Authentic activity, in which, similar to Hodson, students are involved in inquiry-based, hands-on, minds-on activities that are also socio-culturally relevant to the students' daily life and community.
(3) Metacognition, in which students consider the approaches on how they best learn.
(4) Reflexivity, in which students acknowledge and reflect on how issues of power determine who has access to education and opportunities in life and the role of individuals advancing and sharing new knowledge.

The literature on culturally-based teaching indicates a broad spectrum of understandings and practices that constitute multicultural practices in the classroom, as shown in Figure 2.1

Figure 2.1

Spectrum of Ideologies for Teaching Multicultural Students

- No acknowledgement of diversity.
- Acknowledgement but lack of meaningful action.
- Acknowledgment of diversity and the assimilation of traditionally marginalized populations into the practices of the dominant culture.
- Incorporating acknowledgement of diversity into pluralistic curriculum designed to encourage the dominant culture to celebrate the many points of view provided from multicultural settings.
- Development of culturally responsive practices to mitigate the alienation and disenfranchisement of traditionally marginalized populations.
- Development of social justice pedagogy that incorporates understandings of privilege and equity into the content discourse.
- Engagement in sociopolitical and socio-transformative actions which seeks to empower traditionally marginalized students through active research, actions focusing on making positive changes within their communities, and understanding the process by which the voices of traditionally marginalized peoples can be made more public.

2.11 Studies of Pre-Service Teacher Beliefs about Cultural Diversity

Although acknowledgement of increasing diversity in the school population and continued gaps in performance along racial, cultural, and linguistic lines has become more salient in the discussion of science education, the study of teacher understandings on diversity is not a new phenomenon. Grant and Secada (1990) highlighted the need for such research stating:

> A basic tenet of education is that instruction should follow development. Yet we have no maps of how teacher cognitions, beliefs and skills with respect to the teaching of diverse student populations actually develop. We do not know what a beginning teacher really

knows versus what successful, experienced, colleagues might know about the teaching of diverse student populations. If we could map how teachers move from the former to the latter, we might be able to plan teacher education programs to help teachers better develop these skills. (p. 419)

Before looking into the beliefs of pre-service teachers, it is important to understand the demographic trends that underlie the discussion of diversity in instruction.

Demographic studies of teachers have shown that there has long been and continues to be a gap in the racial makeup of teachers in comparison to the racial and ethnic makeup of the students they serve. Since 1987, the United States Department of Education has administered a Schools and Staffing Survey every four years. Data from the National Center for Educational Statistics shows that in 2012 less than approximately 18% of public school teachers came from culturally diverse backgrounds, with the remaining 82% identifying as White (Loewes, 2017). Data from the 2015-16 administration of the renamed United States Department of Education National Teacher and Principal Survey shows that at 80% of teachers in the United States are White. The racial and ethnic makeup of full-time teachers in the period between the two administrations has shown a slight increase from 8% to 9% among Hispanic teachers, and no significant changes in the 7% of teachers who identify as Black or 2% of teachers who identify as Asian (Loewes, 2017).

Although unintentional, many White teachers "participate in the reproduction of racial inequality" (Hyland, 2005, p. 429) when teaching students of color. For example, research on the beliefs and understandings of prospective teachers indicates that in general prospective teachers do not fully recognize that culturally diverse students come from very different backgrounds, and that the customs, values, beliefs, language, ways of communicating, and traditions may greatly differ from those of the dominant cultures students. As a corollary, many pre-service teachers do not understand the cultural differences underlying choices that individual students make and that their understandings of material are powerfully affected by cultural lenses stemming from their home cultures (Diller & Moule, 2005; Tatto, 1996).

Bryan and Atwater (2002) found that most pre-service science teachers “enter their undergraduate programs with little or no intercultural experiences and with beliefs and assumptions that serve to undermine an equitable education for students of culturally diverse backgrounds” (p.832). They also found that science teacher education programs often fail to prepare teachers to work in diverse settings because teachers remain uninformed about the lives and communities of culturally and linguistically diverse students. Furthermore, these pre-service teachers leave their programs not having significant opportunities to confront their own beliefs, stereotypes, and prejudices to move into teaching in settings that may have a greater number of culturally diverse students.

In a study on culturally responsive teaching among pre-service teachers, Siwatu (2011) found that in a program that has a focus on preparing teachers for diversity in the classroom, it is important to emphasize that becoming a culturally responsive teacher requires developing both the skills and self-efficacy necessary to put the new skills to use. His work found that although coursework plays a major role in the development of pre-service teacher knowledge of culturally responsive teaching, the teachers developed neither the procedural knowledge nor the self-efficacy to put new practices into effect. This finding was attributed to a lack of opportunity to use the concepts as part of their education. Similar to Bryan and Atwater’s (2002) findings, the teachers found that they were ill-equipped to face a diverse school setting.

In a study of pre-service teacher beliefs on diversity, Taylor and Sobel (2001) found that most participants came from White middle- and upper-class backgrounds, and as such reported having had limited interactions with people of differing cultural backgrounds and limited knowledge of the historical contributions made by individuals whose backgrounds differ from that of the dominant US culture. Overall, the participants indicated they wanted to be effective teachers of all learners and be prepared to do so in diverse settings; however, less than half the participants indicated having meaningful ties with anyone of a different cultural background, had rarely considered or directly experienced the impacts of inequity in their own education, and had difficulties in addressing the impacts of culture and language on students' relationships with the content.

A study by Bianchini, Cavazos, and Rivas (2003) focused on a small cohort of secondary science student teachers' understandings of topics that were deemed to be at the intersection of equity and science education--who scientists are, how science is practiced, and the ways science is situated in social, cultural, and political contexts. Science student teachers disagreed over who can be considered a scientist and held different conceptions of how science is practiced, ranging from stringent adherence to a strict scientific method routinely outlined in science textbooks to acknowledging various methodologies of science that can include informal indigenous science practices. Regarding the role of science education in equity, pre-service teachers recognized that scientific membership, or exclusion from research and participation, is both important in the setting of societal norms and is at the same time influenced by the norms themselves. Furthermore, Bianchini et al. found that the beliefs on all three components (who scientists are, how science is practiced, and the ways science is situated in social, cultural, and political contexts) changed over the course of a yearlong seminar focusing on the issues.

2.13 Theoretical Framework

Critical Race Theory

As this study focuses on exploration of the beliefs and attitude of science teachers in regards to working with students of multicultural backgrounds, it is guided by principals of Critical Race Theory, which seek to examine questions of race, power, and inequality in education and society and confronts the beliefs and practices that enable racism to persist at a systemic level. Critical Race Theory contends that “the social world, with its rules, practices, and assignments of prestige and power, is not fixed; rather, we construct it with words, stories and silence” (Delgado & Stefancic, 2013. p.44).

Much like the field of multicultural education, Critical Race Theory emerged in the 1970’s. Critical Race Theory has its roots in Critical Legal Studies, which proposed the need to review contradictions on how the legal system impacts different groups under different circumstances. Critical Race Theory began as a critique by legal scholars Derrick Bell, Alan Freeman, and Richard Delgado on the legal system’s slow progression and inability to adequately address the impacts of race and racism on people of color. Critical Race Theory recognizes racism as a permanent and systemic component of society (Bell, 1995) and identifies Whiteness as a property, which determines a person’s level of status, access, and representation in society and the legal system, and ultimately becomes a normative standard by which other groups are measured (Crenshaw et al., 1995; Harris, 1995). Critical Race Theory focuses on the use of counter narratives of the success of individuals and groups that are able to thrive in the face of racism as a tool for addressing those normative beliefs (Delgado & Stefancic, 2001; Matsuda, 1995). Critical Race Theory also takes a measured view of progress examining how the push for equity and equality is a factor of interest convergence and measures the gains that White society receives for the concessions it makes (Bell, 1980). Critical Race Theory critiques the traditionally liberal ideas of colorblindness, neutrality of the law, and incremental change and how these seemingly positive ideals can undercut policies intended to address societal inequities (Gotanda, 1991). Critical Race Theory also recognizes the importance of intersectionality, or the interaction of race with other identity marker characteristics (i.e., nationality, gender, etc.) that impact how an individual or group is viewed.

The lens of Critical Race Theory was brought into the field of educational research in 1995 by Gloria Ladson-Billings and William Tate IV, in their seminal article *Toward a Critical Race Theory of Education*, stating "(1) race continues to be significant in the United States; (2) US society is based on property rights rather than human rights, and the intersections of race; and (3) property creates an analytical tool for understanding inequity" (p. 47). In so doing, the authors address that education in the United States has a normative structure based around dominant White culture and values and that systemic structures impact students of ethnic and multicultural backgrounds.

Dixson and Anderson (2018) indicate that many of the issues underlying the field of Critical Race Theory continue to exist to this date and identify six boundaries for Critical Race Theory and education that are consistent with the work of Ladson-Billings, Tate, Bell, Freeman, Delgado, and other advocates of Critical Race Theory. Dixson and Anderson reiterate that the purpose of Critical Race Theory is to examine the "logical outcome of a system of achievement presided on competition" (p. 122). They assert that Critical Race Theory in education must examine the systemic role of educational policy and practices in the construction of racial inequity and the perpetuation of normative Whiteness. Aligned to the counter narratives proposed by Matsuda (1995) and Delgado (2001), Critical Race Theory in education should reject the dominant narrative about the normative superiority of White culture and the subsequent inferiority of people of color, while examining the historical linkages between educational inequity and racial oppression. They assert that Critical Race Theory in education must continue to engage in an intersectional analysis that recognizes the ways that race interacts with other identity markers and advocate for meaningful outcomes that address racial inequities, and not merely document disparities. These purposes inherent in Critical Race Theory parallel perspectives within multicultural education that advocate for the inclusion of practices focused on the dominant culture learning to listen to and understand the inequalities faced by traditionally marginalized groups (Sleeter, 2018), address the needs of the many groups who have been traditionally marginalized (Banks, 1996), and challenge systemic racism in structures and systems of education (Sleeter, 2018).

2.12 Summary

As the population of the nation, and in turn the populations in classrooms, become more diverse; the concern for preparing all teachers for providing rigorous and meaningful instruction in light of the wide range of needs and points of view of students continues to be a central issue in educational reform (Darling-Hammond, Wise, & Klein, 1997; Melnick & Zeichner, 1998). The need for preparation of this increasingly diverse population to function in a society that places a demand on STEM literacy and career readiness compounds this necessity within the science classroom. Nearly half a century after Smith's *Teachers for the Real World* (1969) identified the hurdles of instruction of marginalized students as (1) unfamiliarity with student backgrounds, (2) lack of understanding of teachers own prejudices and values, and (3) lack of skills needed to work effectively with students of various backgrounds, policies in science education, such as NGSS, and teacher education programs, such as Teachers Colleges, have only recently begun to address the issues of diversity in science instruction. The process of defining and incorporating national and state policies into instructional practice can take a significant amount of time as they move through the separate stages of implementation talk, policy action, and actual implementation (Elmore, 2003; Tyack & Cuban, 1995) and can result in surface level changes that are ultimately unsuccessful due to their not addressing the root issues and understandings of the policies (Cohen & Hill, 1999). And although teacher education programs may have begun addressing issues of diversity and equity among new teachers, the processes of socialization and culturalization that occur as new-teachers become a part of the educational system can lead to a perpetuation of the status-quo beliefs and practices regardless of their motivation or enthusiasm to affect change (Jex & Britt, 2008; Kaestle, 1993; Wineberg & Grossman, 1998).

Adding to the barriers of incorporating multicultural awareness and instruction as part of science instruction, current science standards and curricula continue to be based in what Goodlad (1990) called a monocultural approach in context of a tiered science curriculum stemming from standards for college preparedness dating back to the turn of the 20th century. Curricula and instructional practices that have historically benefited White, middle-class students, to the contrary have largely failed to provide quality instruction for traditionally marginalized and alienated students coming from culturally, ethnically, and linguistically diverse backgrounds (Melnick & Zeichner, 1998; Tyack & Cuban, 1995).

Addressing the strengths and needs of a diverse student body within national and state science standards and policies is a vital part of developing education that incorporates the ideas of “Science for all.” Moreover, there must be a continued focus on university preparation of new teachers for dealing with the facets of diversity and understanding the many forms of multicultural education. This is a pivotal aspect for developing a culture of science instruction that supports an increasing multicultural society. However, I posit that the root of implementation of any form of multicultural or equity pedagogy lies within the practices of in-service teachers, as well as pre-service education, and thus it is important to understand how in-service science teachers view diversity and the inclusion of diversity in their pedagogy.

A recent study on the attitudes and beliefs of mathematics, science, and social studies teachers on working with culturally and linguistically diverse students identified that although the teachers reported that the students' cultural differences presented valuable assets in the classroom, most of the teachers in the study were not well versed in the use of cross-cultural communication patterns; and they generally demonstrated negative attitudes towards implementing accommodations for diversity in their content areas (Khrais, 2013). The study cited that there were differences noted between the attitudes of social studies teachers and those of mathematics and science teachers, though there was no mention of within group comparisons for science teachers. In the next chapter, I outline the methodology and sources of evidence used in this study to explore the beliefs and attitudes of in-service secondary science teachers of differing content area specialties (i.e. biology, chemistry, Earth science and physics) on working with students of multicultural backgrounds.

Chapter 3: Methodology

3.1 Initial Investigations

Prior to this research, a pilot study was conducted that consisted of open-ended conversations with four science teachers stemming from the question “What role does diversity play in the context of your teaching of science?” At the time of the pilot, I was the immediate supervisor for the four teachers who all taught in the same suburban high school science department. The school district was of interest to me, not only because of my professional ties to the district, but because the district had undergone shifts in the racial and ethnic makeup of its student body over the course of the recent decade. According to New York State Education Department (NYSED) school report cards (2003, 2013), the high school population of White students decreased from 72% to 52% between 2003 and 2013. At the same time the population of Latino students increased from 8% to 19%, the population of Asian students increased from 4% to 12%, and the population of Black students remained relatively stable moving from 16% to 17%.

Analysis using a process of open coding (Strauss & Corbin, 2007) indicated potential differences in the beliefs and attitudes of teachers of different science subjects regarding working with students of multicultural backgrounds. The biology teachers indicated that being from a multicultural background could influence a student’s needs and performance in class. As such, the teachers indicated they often made special considerations in the instruction to address the needs of students from multicultural backgrounds. The teachers of chemistry and physics indicated that they did not view the cultural background of a student as having an impact on the student’s performance and as such did not make many accommodations based on cultural background.

Discussion of Pilot Findings

From an initial open-ended coding of the conversations, themes began to emerge. Teachers in traditionally introductory science courses, such as freshman biology, referenced diversity and factors they associated with traditionally underserved communities as influencing the performance of their students. This was attributed to having a richer diversity of students in these classes. From the information presented by the biology teachers, they had more students coming from more traditionally underserved populations. Additionally, the biology teachers' beliefs and attitudes on the necessity of addressing diversity appeared to stem from increased interactions with students of diverse backgrounds. The comments from the teachers of introductory classes indicated greater familiarity with social and language barriers as well as recognition of issues that affect students outside of classrooms.

Betty, a White female freshman biology teacher with 22 years of experience stated, "I see that a lot of the minority students have a harder time with the material. But I try to use examples from their lives to make connections to the material and I guess I connect with them because of that." Similarly, Brooke, a White female freshman biology teacher with six years of experience, stated, "It may sound like a generalization but on the whole some the minority students are a little more disadvantaged when it comes to my class. Many don't come in with the same kind of prior experiences in the classroom or outside of the classroom and don't connect to the material as easily."

Conversely, teachers of honors courses and courses, such as physics, that have traditionally been associated with upper levels of science achievement showed little concern for a need to understand the diversity of their students. The comments from these teachers indicated that their beliefs on science education were more focused on what they perceived as the objective nature of science content and that there should not be much need to address diversity in the context of objective curriculum.

Phil, a White male physics teacher with 18 years of experience, stated, “When it comes to physics, I don’t think that it should matter if a student comes from a minority background or not. Physics at the high school level is fairly straightforward. The concepts are the same, and the mathematics is the same, and the test that the students take at the end of the year is the same regardless of who the student is.” Similarly, Chris, a White male honors chemistry and Advanced Placement Biology teacher with 12 years of experience, stated, “I never really had to give much thought to diversity in my classes. Trying to connect based on race doesn’t seem appropriate in a class that is more objective in nature.”

During the interviews, a second theme that emerged was the placement of some students into elective classes instead of continuing through the traditional sequence leading to physics. Brooke indicated that “students who have a lot of background in science and mathematics do well on the tests at the end of the year and go onto the honors courses, but a lot of the minority students who struggle move onto Earth science and then take electives like forensics or marine biology instead of going on to chemistry.” Betty indicated that “a lot of the honors classes don’t have to deal with the issues of tough home lives or students who don’t have time because they have to work at a job or take care of family after school,” adding that, “a lot of the minority students are the ones who have these problems and don’t move onto physics or honors classes.” Phil indicated that the minority students in his classes “were just as likely to do well as his White students.” But when asked if he thought his classes had the same ethnic makeup as the freshman classes, he stated, “I never really thought about that . . . I guess they don’t, but I don’t know if that's because the students weren't recommended for the honors classes or because they chose not to go into them."

This preliminary study left me wondering if what I saw as differences between biology, chemistry, and physics teachers were an artifact of these particular teachers or if the beliefs and attitudes of the science teachers were more common across larger samples of science teachers and if any such differences could be correlated to the areas of certification (i.e., biology, chemistry, physics, and Earth science) that the teachers associated themselves with. The findings of the pilot study helped me to design the current study. There is an expansion of ideas and issues as I looked at the emerging themes presented by science teachers as they discuss multiculturalism in their science classrooms during the course of this larger study.

3.2 The Current Study

The purpose of this dissertation study was to understand the beliefs and attitudes of science teachers in regard to working with culturally diverse students and to determine if there are differences based on area specialties (i.e. biology, chemistry, Earth science, and physics). If such differences did exist, the study looked to also identify factors that may be attributed to these differences. This study utilized a mixed methods approach that was initiated through a grounded theory approach, beginning with quantitative analysis of responses to a survey instrument using Likert-items, and followed up with qualitative analysis of a series of interviews from a purposively sample of teachers across the four science content areas. This investigation addressed the following questions:

1. How can we characterize differences in the beliefs and attitudes of in-service secondary science teachers of different content specialties (i.e., biology, chemistry,

physics, and Earth science) in working with multicultural students in secondary science classroom settings?

2. What underlying factors attribute to the patterns of differences and similarities when comparing the beliefs and attitudes of secondary science teachers of different content specializations in regard to multiculturalism in the science classroom?

3.3 Grounded Theory

This study, in both its qualitative and quantitative aspects, applies principles of grounded theory. Grounded theory, originally developed by Glaser and Strauss (1967), is a qualitative method of study from the field of sociology that seeks to construct objective understandings and develop a "unified theoretical explanation" (Corbin & Strauss, 2007, p.107) about significant phenomena that impact people's lives (Glaser, 1978). Grounded theory posits that theory should be "grounded" in the actions, interactions, and social processes observed in the field with the purpose of developing an explanatory theory shaped by the views of a large number of participants (Creswell, 2013). Grounded theory research studies use generative questions to guide the research and gather data towards the formation of core theoretical concepts (Trochim, 2001). The questions come from an in iterative process of simultaneous data collection and data analysis, with the two processes supporting one another throughout the research (Charmaz, 2014). The process follows a format of open coding of data, predominantly from interviews, to determine a central phenomenon followed by axial coding of the data to determine the contexts, conditions, and consequences that influence or are influenced by the central phenomenon.

Though the field of grounded theory began as a collaboration between Glaser and Strauss, over time there has been a divide among the founders and subsequent practitioners of grounded theory based on varying beliefs of how the application of literature reviews may lead investigators to have preconceived ideas, instead of allowing the data to tell the whole story (Mills, Bonner, & Francis, 2006). Glaser, and proponents of Classical Grounded Theory, view research as an inductive process in which objective and positivist examination of data leads to the emergence of a central phenomenon. Strauss and Corbin (1994) have broadened the scope of grounded theory by taking the position that truth is enacted and influenced by prevailing beliefs of the time, thus making it impossible for theory to be completely free of bias, leading to the development of Straussian Grounded Theory. Grounded theory has been further broadened by the development of Constructivist Grounded Theory, which posits that understandings can be relative to perceptions of reality (Charmaz, 2003) and that the researcher and the participants construct a shared reality as data is collected and analyzed (Charmaz, 2006).

At the inception of this study, I attempted to adhere to an objective view of the phenomenon surrounding perspectives of multiculturalism in the science classroom and attempted to refrain from engaging with the emotionally charged views that can be part of the discussion of a subject matter such as multiculturalism. This attempt at objectivity can be seen in the statements developed in the Survey of Multiculturalism in Science Classrooms. It was only after several iterations of looking through the quantitative data that themes regarding personal views and professional attitudes emerged. Understanding that such themes are independent of neither the bias of the participants nor, ultimately, the bias of the researcher, the underlying work of the research pivoted to a more Straussian approach to grounded theory. Had the interviews during the qualitative data collection and analysis periods included multiple meetings with each participant instead of a single interview, it is quite likely that the study would have developed further into a Constructivist grounded theory approach with a possibility of the research itself impacting and evolving the views of participants and researchers over the course of the study.

Initiating Grounded Theory

As indicated above, a Straussian grounded theory approach was ultimately determined to be the appropriate methodology for research design because it allowed for the review of multiple means of data collection and analysis to develop theories underlying the phenomenon identified during the course of the study. This methodology also allowed the central ideas to arise from an inductive review of the collected data while taking into consideration the subjectivity associated with the central theme of multiculturalism, as well the emergent themes of teacher attitudes and teacher beliefs.

The study ultimately sought to understand how secondary teachers in science engage with the construct of multiculturalism, if there are patterns of differences in the beliefs and attitudes of teachers of different science discipline in engaging with multiculturalism and what underlying phenomenon may impact any identified differences. In the fashion of grounded theory, the principal research questions of this study had potential differences that originated form reviewing the responses of participants to a series of open-ended conversations around the general question of "What role does diversity play in the context of your teaching of science?" Though the teachers who participated in the initial investigations did not directly discuss elements of inequity, there was a distinction in the experiences of the freshman biology teachers and the physics and chemistry teachers around their dealings with students of diverse backgrounds. During this period of what can be considered open coding (Strauss & Corbin, 1990), a theme began to emerge that teachers of the different disciplines within science have differing views and experiences toward the inclusion of culturally relevant practices within their instruction. These preliminary conversations led to the eventual development of a survey instrument that allowed for collection of both quantitative and qualitative data and was subsequently followed up with additional data collection based on a series of interviews. As described by Charmaz (2014), the inclusion of the qualitative grounded approach allows the researcher to collect new data and follow up on emergent data throughout the research process.

This survey as a whole took an iterative and grounded approach by first reviewing the initial quantitative survey data for emergent themes, reevaluating the data in context of the emergent themes that were identified, and then continuing the development of these themes through collection and analysis of additional qualitative interview data. Initial Likert response data were collected using the Survey of Multiculturalism in the Science Classroom instrument that was developed for this study, as will be presented later in the section of the *Qualitative Approach* detailing the *Instrumentation Design*. The quantitative data was analyzed through comparison testing, correlation network analysis, and review of Likert responses to determine emerging patterns. These patterns were analyzed both in terms of how the items correlated to one another and in terms of how responses in ties differed based on the subject specialties of the participants. Initial review of the responses to the survey, along with themes that began to emerge from the initial interviews, resulted in the identification of potential differences in the attitudes and beliefs of teachers based on content specialties, the possibility of differences in the interactions of attitudes and beliefs for the different content areas, and initial theories about underlying phenomenon that may lead to such differences. This initial analysis led to the overarching guiding question for this study: How can we characterize the differences in the beliefs and attitudes of in-service science teachers of different disciplines in regard to cultural diversity in secondary science classrooms?

3.4 Overview of the Study Design

The study utilized a mixed method approach to examine the beliefs and attitudes of secondary science teachers on multiculturalism, with an iterative analysis of the data from both parts of the study that allowed for the two sides of the research to inform one another. The primary tool used in the initial quantitative stage of the study was the Survey of Multiculturalism in the Science Classroom (SMSC), which was developed for this study and distributed through channels of the National Science Teachers Association (NSTA). The SMSC used Likert-scale items to capture the overall beliefs and attitudes of science teachers from an internet-based survey. The second qualitative stage of this study followed up on the SMSC with a series of open ended interviews with teachers on their experiences around working with students of multicultural backgrounds, with the understanding that interviews have been accepted as the most appropriate means of "revealing the nature of teachers' thinking and worldviews" (Jones and Carter, 2013, p. 1076). As outlined by Mays and Pope (1995, p.184), the collection of quantitative data from the SMSC was collected at the beginning of the study. Qualitative interviews were conducted concurrent with the statistical analysis to create interview questions informed by the patterns that emerged from the quantitative studies. The results of these qualitative interviews in turn drove subsequent review and further analysis of the data collected as part of the quantitative portion of the study.

For the quantitative portion of the study, the Likert items from the SMSC were grouped using factor analysis and the teachers were grouped based on content area of specialty (i.e. biology, chemistry, Earth science, and physics). The analysis included comparisons of the responses of the independent content areas groups based on descriptions of the trends in the responses to the Likert items, results of non-parametric comparison tests, and inter-correlation matrix analysis (e.g., Anderson, 2016).

The qualitative portion of the study was comprised of single session interviews with teachers who had previously completed the SMSC. Though there was an interview protocol developed to guide the sessions, the grounded theory based methodology led to the interviews incorporating lines of questions that evolved from themes that emerged from the iterative analysis of earlier interviews (Boeije, 2010) and patterns emerging from the quantitative work.

The analysis of the data gathered from the qualitative and quantitative stages of the study were then compared, as detailed in Table 3.1, to triangulate findings of the study. Details of the data collection and analysis are discussed in more detail in the Quantitative Approach and Qualitative Approach section that follow.

Table 3.1

Data Collection Matrix

Research Question	Data Collection Procedure	Data Analysis
1. How can we characterize differences in the beliefs and attitudes of in-service secondary science teachers of different content specialties (i.e., biology, chemistry, physics, and Earth science) in working with multicultural students in secondary science classroom settings?	Likert items from SMSC	Comparative Testing Kruskill- Wallis Mann - Whitney U Network Correlation Analysis Patterns of Responses
	Interviews	Open coding, axial coding, selective coding
2. What underlying factors attribute to the patterns of differences and similarities when comparing the beliefs and attitudes of secondary science teachers of different content specializations in regard to multiculturalism in the science classroom?	Interviews	Open coding, axial coding, selective coding

3.5 Quantitative Approach

Instrumentation Design

The Survey of Multiculturalism in the Science Classroom (SMSC), which is presented in Appendix A, consisted of 18 demographic questions, 54 Likert statements, and 14 open response questions and was developed during a Dissertation Seminar course. The items were reviewed by a panel of eight doctoral candidates and three professors to ensure that the questions were appropriate to the subject of teacher beliefs on multiculturalism and cultural diversity in the instruction of science. Initially the use of a 42-question Likert scale, developed by Pohan and Aguilar (2001), measuring educators' personal and professional beliefs about diversity, was proposed for this part of the study, but upon review by the panel it was determined that only 12 of the 42 questions directly related to the concept of multiculturalism and cultural diversity. Using the 12 questions that could be adapted from Pohan and Aguilar, along with guidance stemming from unpublished doctoral work on attitudes of middle school mathematics, science, and social studies teachers by Nadia Khrais (2013), a 66 question survey was developed consisting 18 Demographic questions and 48 Likert Scale questions. This earlier version of the SMSC was piloted using Google Forms through a posting on a university message board, presenting the survey to three classes of graduate students in science education, and inviting volunteers from two suburban science departments that I was working with at the time. From these recruitment strategies, 87 responses over a two-week period were collected. The pilot survey also contained a section for feedback on the survey design.

Based on the feedback from the pilot of the SMSC and discussions with the panel of reviewers, several Likert statements were modified for clarity, four Likert statements were eliminated, three statements were redesigned into multiple questions, and four new statements were added. In addition, several free response questions were added to the survey, including an opportunity to make an optional comment on the statements or responses at the end of every four to nine statements; this addition was based on an overwhelming response in the comments section of the pilot indicating that participants felt the need, but did not have the opportunity, to extrapolate upon the statements or their responses over the course of the survey. The updated version of the SMSC was uploaded to the Qualtrics platform for electronic distribution and became the primary instrument for the quantitative portion of the study.

Quantitative Data Collection

The SMSC was uploaded onto the Qualtrics data surveying platform and distributed through email to members of NSTA who had subscribed to receive emails from one of five listservs within the organization: (1) pedagogy@lis.nsta.org, (2) biology@lis.nsta.org, (3) chemistry@lis.nsta.org, (4) physics@lis.nsta.org, and (5) earthscience@lis.nsta.org. Though the NSTA has a membership base of 55,000 teachers spread across the United States, it is uncertain how many may be subscribed to these lists, and some members may be subscribed to multiple lists. The SMSC was initially distributed in May of 2016 and remained open until November 2016, with a second call for participants distributed along the same channels in October of 2016. Of the 221 respondents to the SMSC, 152 met the criteria of being certified science teachers who were actively teaching science at the secondary level. The 69 respondents who did not meet the criteria for the study represented non-secondary teachers, non-certified teachers, teachers certified in subjects other than science, and science educators that were not teachers. The data was removed from the current analysis but retained for possible further studies of the data. The remaining 152 respondents were then categorized based on their responses to their primary area of certification yielding in content area groups consisting of 67 biology teachers, 44 chemistry teachers, 22 physics teachers, and 19 Earth science teachers. Demographic data for the 152 participants included in this study are presented in table 3.2.

Table 3.2

Participants in Survey of Multiculturalism in the Science Classroom (SMSC)

		All Teachers (n = 152)	Biology (n = 67)	Chemistry (n=44)	Physics (n=22)	Earth Sci (n=19)
Gender	Male	50	22	12	13	3
	Female	102	45	32	9	16
Race	White / Caucasian / European Descent	138	59	43	19	19
	African American (non-Latino)	2	1	1	0	0
	Asian / Asian-American / Pacific Islander	6	5	0	2	0
	Latino / Latina	1	1	0	0	0
	Multi-racial	2	1	0	1	0
Age	20 to 29 years	8	4	2	1	1
	30 to 39 years	32	14	8	4	6
	40 to 49 years	38	18	10	6	4
	50 to 59 years	49	20	16	6	7
	60 to 69 years	20	11	7	4	1
	70 or over	2	0	1	1	0
Years as a Teacher	1 to 3 years	6	3	2	1	0
	4 to 10 years	38	14	12	7	5
	11 to 20 years	63	22	24	8	10
	21 to 30 years	34	25	3	5	3
	31 years or over	8	3	3	1	1
School Setting	Urban	54	23	17	9	7
	Suburban	67	30	17	11	10
	Rural	28	14	10	2	2

Quantitative Data Analysis

Quantitative analysis of data from the survey was conducted using the SPSS statistical package for the analysis of demographic data and responses to the 54 Likert items. Exploratory factor analysis was used to group the 54 Likert items into five factors based on the response patterns of participants, namely: (1) Personal Beliefs and Professional Attitudes on Multiculturalism, (2) Cultural Norms in Curriculum and Instruction, (3) Challenges and Concerns Related to Working with Students of Multicultural Backgrounds, (4) Instructional Practices, and (5) Teacher Preparation. These groupings of items were then used for subsequent analysis.

Differences in responses between the teachers of different content areas was studied thorough step wise implementation of comparison tests for the Likert items in the SMSC. Due to the ordinal nature of the Likert data, non-parametric analysis was conducted for each question using the Kruskal-Wallis test to determine if there were statistically significant differences in responses among the teachers of different subject areas.

For questions in which there was evidence of a statistically significant difference among teachers of different content area specialties, Mann-Whitney U testing was performed for all six paired combinations to determine which paired comparisons of content areas presented statistically significant differences between their responses. General patterns of responses to the Likert items were analyzed to identify directionality and patterns in the responses of all teachers and content area groups of teachers.

Intercorrelation network analysis (Anderson, 2016) was used to analyze the relationships among Beliefs and Attitudes on Multiculturalism across the groups of teachers from the different science disciplines, because it represented the beliefs and attitudes of the respondents as deduced from the composite analysis of all of their responses to the Likert items. This analysis was used to visualize the patterns of correlations for all respondents and content area groups based on the number of items (nodes) that were present in the correlation network and the number of connections between the nodes.

3.6 Qualitative Approach

Interviews and Participants

Teacher interviews were conducted between April and December of 2016. Twelve teachers from two secondary schools, both with which I had prior affiliation, were contacted for interviews. Six of the participants were teaching in an urban high school setting at the time of the interviews and six teachers were teaching at a suburban high school located approximately 30 miles away from the first.

All 12 volunteers were certified secondary science teachers who had completed the SMSC and had indicated at the end of the survey that they were interested in taking part in follow up interviews. Table 3.3 provides a summary of information about the participants. For ease of the reader, the first letter of each participant's pseudonym correlates with the first letter of the content are they represent (i.e., Blanca is a biology teacher, Chris is a chemistry teacher, Pam is a physics teacher).

The sample of interview participants represented teachers from all four content areas in the two settings. Of the six teachers in the urban school setting three were biology teachers, one was a chemistry teacher, one was an Earth science teacher, and one was a physics teacher. Of the six teachers from the suburban school setting two were biology teachers, one was a chemistry teacher, one was an Earth science teacher, and two were physics teachers. The distribution of teachers across two schools allowed for comparisons of the interactions of teachers with different content specialty with students across the same setting.

Table 3.3

Interview Participants

Teacher Alias	Primary Certification	Race	Gender	Age Range	Years Teaching	School Setting
Betty	Biology	White	Female	60 to 69	21 to 30	Suburban
Brooke	Biology	White	Female	30 to 39	4 to 10	Suburban
Blanca	Biology	Latina	Female	60 to 69	21 to 30	Urban
Badra	Biology	Asian	Female	60 to 69	11 to 20	Urban
Beatrice	Biology	White	Female	40 to 49	11 to 20	Urban
Cathy	Chemistry	Asian	Female	40 to 49	11 to 20	Urban
Chris	Chemistry	White	Male	30 to 39	11 to 20	Suburban
Emma	Earth Science	White	Female	20 to 29	4 to 10	Suburban
Elise	Earth Science	White	Female	30 to 39	11 to 20	Urban
Peter	Physics	White	Male	60 to 69	21 to 30	Suburban
Phil	Physics	White	Male	60 to 69	11 to 20	Suburban
Pam	Physics	Asian	Female	50 to 59	11 to 20	Urban

Additionally, because of the sensitive nature of the topic being discussed and based on principles of constructivist grounded theory, it was assumed that prior experience in working with me would add to the level of comfort for the teachers and allow discussion of what was a shared reality for the teachers and me as a researcher (Charmaz, 2006).

Though the participant size of 12 participants in the interview is considered a small theoretical sample size for a study initiating grounded theory research, the disadvantage of a low number of participants was balanced against the potential advantages of my prior relationships with the participants yielding honest and candid responses about what is often considered a sensitive subject. To further balance the disadvantages of the small theoretical sample in the qualitative interviews, the results of the analysis of the interviews were compared, wherever possible, to the results from the quantitative data analysis which had a larger size 152 participants.

In terms of my role as a researcher, working with teachers in these particular settings allowed me to be knowledgeable about the realities in which the teachers operated, both in regards to the focal area of study (i.e., multiculturalism in the science classroom) and areas other than the central issues of study (i.e., school demographics, histories of the neighborhoods served by the schools; common practices of students and teachers etc.) that may impact the responses of the participants (Glaser, 1978). The in-person interviews were conducted on-site at the schools where the teachers taught; the six urban setting teachers were interviewed over the course three visits made during the course of a single week and the six suburban teachers were interviewed over the course of two visits that were spaced out two weeks apart. The 12 participants were each interviewed once in person for a span of 35 to 43 minutes and were either visited briefly during a subsequent visit or contacted by email to review the major themes that had been discussed during the interviews, clarify any comments they had made, or answer any questions that they had after the interview.

Interviews began with the protocol outlined in Appendix B but allowed for open ended questioning to probe into the responses of the participants (Krippendorf, 1980). As the study progressed, questions asked of participants also addressed themes (codes) emerging from analysis of the interviews of prior participants and the data emerging from the quantitative approach. Member checking was conducted throughout the interviews by paraphrasing participant comments and asking them to verify what had been understood and with a brief follow-up during a subsequent visit to the school or through an email message.

Qualitative Analysis

Once the interviews were transcribed, the first iteration of data analysis utilized open coding to identify key fragments from the conversations (Strauss & Corbin, 2007). The fragments were compared among each other and grouped into categories based on common themes. Examples of interview fragments coded under separate themes can be found in Table 3.4. This process of open-coding at the start of the analysis process "provides an analytic handle on the data … [and] contributes to clear organization of the data" (Boeije, 2010, p.96). The open coding phase required multiple readings of the transcripts until validation of the coding was achieved through the saturation point at which no new codes were necessary to label the sentence fragments.

Because several of the interview questions were written to reflect items from the SMSC, several codes aligned with the themes presented in the survey. For example, the theme of *identifying students as having multicultural backgrounds* was addressed in both the quantitative and qualitative sections of the study. Survey Item 11 (It is important to identify the cultural backgrounds of the students in my classes) addressed the theme as a Likert statement in the SMSC. During the interviews the theme of identifying multicultural students was further explored and fragments that specifically addressed the identification of students were coded for the larger theme. As illustrated in Table 3.4, the comment of "they [students of multicultural backgrounds] still speak in other languages with their friends" made by Betty and the comment of "when we talk about hurricanes or monsoons, a student who's culture and experiences come from a place that has hurricanes or monsoons is more connected and can share their experiences" made by Elise were both coded for the general theme of *identifying student backgrounds*.

Table 3.4

Examples of Interview Fragments and Coding

Participant	Interview Fragment	Code	Theme
Chris	It's a broad world that we live in and we have to be open to it all because it's by sharing our different experiences and views that we evolve and grow as individuals and as a civilization	Positive personal belief	Personal beliefs on multiculturalism
Betty	I give my students a survey at the beginning of the year that asks them about their background that includes if they either lived in or came from somewhere outside of [this school district]	Use of survey	Identifying students as multicultural
Betty	they still speak in other languages with their friends	Language as identifier	Identifying students as multicultural
Elise	when we talk about hurricanes or monsoons, a student whose culture and experiences come from a place that has hurricanes or monsoons is more connected and can share their experiences	Making personal connections to content.	Identifying students as multicultural
Blanca	A lot of newer students coming from some countries in Central America didn't have the same structure of education and need extra help to understand concepts that I may take for granted when working with students who have grown up here.	Prior educational experiences	Identifying students as multicultural
Emma	I've noticed that a lot of the Black or Hispanic students choose to take electives instead of chemistry after Earth science when given the option.	Exiting to electives	Representation in science classes

Table 3.4 (continued)

Examples of Interview Fragments and Coding

Participant	Interview Fragment	Code	Theme
Betty	When I have passed through the rooms [of physics or chemistry classes], I'd say those classes are mainly White or Asian	Unequal representation in upper level courses	Representation in science classes
Elise	I don't know if it's worth it for some students to be taking chemistry or physics if they were already struggling	Negative success in science, Impact on progression	Attitudes on student success
Brooke	I never received any formal training, a lot of what I try is based on what I think they [ENL students need] and some ideas I've gotten talking to other teachers	No formal training, Trial and error	Teacher Preparation

Some themes, such as *representation of multicultural students* [in specific science classes] had not been addressed in the Likert items of the SMSC but emerged from the questions asked on the interviews. Table 3.4 also illustrates how both Betty's statement of "When I have passed through the rooms [of physics or chemistry classes], I'd say those classes are mainly White or Asian" and Emma's statement that "I've noticed that a lot of the Black or Hispanic students choose to take electives instead of chemistry after Earth science when given the option" were coded under the theme of *representation in science classes* as both denoted discrepancies in the racial makeup of chemistry classes or patterns of behavior that led to such discrepancies.

Other themes identified from the interviews included *personal beliefs on multiculturalism, definitions of multiculturalism, teacher preparation, shared experiences, student performance,* and *representation in science classes.*

After an initial list of themes and codes had been developed, the initial analysis was reviewed by a panel of graduate students and inter-rater validity was checked by having the members of the panel code sections of the interviews. The analysis then proceeded into the stage of axial coding during which checks were be made to ensure fragments were coded properly. Similar codes were merged, and dominant and less important codes are identified, and categories were defined (Baxter, 1992; Boeije, 2010).

Through selective coding and debriefings with a smaller panel of graduate students at regular intervals, codes which can account for variability in data were identified based on recurrence within themes, comparison to the initial research questions, concepts presented in the literature, and unanticipated findings that stood out. For an example of this process we can return to the previously cited examples of codes under the theme of *identifying students as multicultural.* Table 3.4 illustrates that Betty's comment about speaking in "other languages with their friends" was coded as *language as an identifier* whereas Elise's comment about experiences from "a place that has hurricanes or monsoons" was coded as *making personal connections to the content* because it illustrated the use of identifying a student's background and experience in context of curriculum. Both interview fragments involved the identification of students as being multicultural, though the first was an example of how students are identified as multicultural and the second references why such identifications are important instructionally.

The statements included in Table 3.4 also demonstrate how the iterative nature of axial coding during the survey led to the development of new codes and themes in the study. Betty's statement of physics or chemistry classes as "mainly White or Asian" was coded as *unequal representation in upper level classes*, and Emma's statement of noticing that "Black or Hispanic students choose to take electives instead of chemistry" was eventually coded as *exiting to* *electives*. In this case, axial coding to find additional fragments related to the representation of multiculturalism in classes led to the parallel inquiry that addressed the placement of students leading to the code of *exiting to electives*. In the fashion of grounded theory research, the development of the later code influenced the questions asked in subsequent interviews.

Throughout the process of qualitative data analysis, the quantitative analysis of responses to the Likert-based questions of the SMSC was reviewed to determine it related to the themes emerging from the qualitative analysis. The comparisons of the multiple quantitative and qualitative methods were in turn used to triangulate findings that developed over the course of the study.

3.7 Limitations and Delimitations

The study uses of the grounded theory to develop understandings of science teachers' beliefs on multiculturalism and diversity in the science classroom. By its nature, grounded theory seeks to construct objective understandings about significant phenomena that impact people's lives through patterns observed in the data collected (Glaser, 1978). In an essay on the use of grounded theory in the context of writing a dissertation, Elliott and Higgins (2012) proffer that the academic requirements of developing a literature review and stating a conceptual framework can bias the researcher towards coding of data to fit preconceived assumptions or perspectives that the researcher may knowingly or unknowingly bring into the analysis of data. As such I acknowledge that I came into this study with my own beliefs and attitudes on providing all students with opportunities in upper level sciences, the need for critical studies on the inclusion strategies to enhance the learning of culturally diverse students, and my assumptions of a relationship of the beliefs of teachers being somehow related to the field of science that they teach. However, because the possibility of different science disciplines impacting teacher beliefs was a theme that emerged as part of piloting a qualitative method to be used in this study, I contend that it is a fitting theme to include in the study.

3.8 Ethical Considerations

Although there are no physical risks for participants in this study, it is recognized that the discussion of cultural diversity, multiculturalism, and the related issues of race, ethnicity, social status, and access to resources may present topics of sensitivity. As such, participants were given the opportunity to omit or bypass questions they felt uncomfortable answering, or if necessary, could terminate any interviews or surveys should they deem it necessary to do so. There were 13 survey participants that terminated the survey before completion, but all 13 represented non-science certified teacher or non-teachers and would not have met criteria for inclusion in the study. There were no interview participants that elected to terminate the interview session due to discomfort with the material, though there were certain items during the interview that teachers indicated they could not answer with certainty. For example, several teacher gave answers to the question “How representative is your classroom of the cultural diversity of the school?” but with the caveat that they were uncertain because they had never considered it. Similarly certain lines of questioning, such as “Are there particular strategies you utilize when working with students with cultural backgrounds different from your own?” which were not pursued because the teacher indicated that they did not see any need to differentiate based on cultural values. Such occurrences will be noted in Chapter 5 (Results of Qualitative Analysis).

Furthermore, to ensure that participants could not be exploited for positing beliefs or statements which may be seen a culturally or socially insensitive, all participants' real names were not recorded in the context of data collection, analysis, or presentation of the survey. Any contact information collected form the survey in regard to follow-up for the interviews was kept in a separate data file form the study data. An inadvertent disadvantage of this precaution was that the survey information for those who participated in the interviews could not later be connected to the analysis of the interviews to examine within-subject validity.

As noted in the methodology section, pseudonyms were used to maintain the anonymity of survey participants, though pseudonyms were created such that first letter of each participant's pseudonym correlates with the first letter of the content are they represent.

It should also be acknowledged that the participants in the survey had prior affiliations with me in the context of a supervisory role, but all interviews were conducted with teachers that did not work with me at the time of the interviews in order to ensure that their comments would not impact them in terms of professional evaluations.

Chapter 4: Results of Quantitative Analysis

This section presents the results for quantitative analysis of the 54 Likert statements that were part of the Survey on Multiculturalism in the Science Classroom (SMSC). Results are presented for the research questions in sequential order and the items from the SMSC have been organized based on factor analysis of the 54 Likert items: (1) Personal Beliefs and Professional Attitudes on Multiculturalism, (2) Cultural Norms in Curriculum and Instruction, (3) Challenges and Concerns Related to Working with Students of Multicultural Backgrounds, (4) Instructional Practices, and (5) Teacher Preparation. The factor analysis of the items resulted in reorganization from the order in which the items were initially presented in the survey. In order to maintain consistency throughout the chapter the grouping of items and the numbering of items will reflect the organization of items as presented in Appendix E.

4.1 Research Question 1

The purpose of this question (How can we characterize differences in the beliefs and attitudes of in-service secondary science teachers of different content specialties (i.e., biology, chemistry, physics, and Earth science) towards working with multicultural students in secondary science classroom settings?) was to examine patterns in the data collected from the Likert statements of the SMSC that demonstrated possible differences that existed between the four content area groups. The analysis of this question was divided into three sub-questions based on the different methods used to investigate the question. The first sub-question used step-wise non-parametric analysis to make between-group comparisons to determine if there were statistically significant differences in the responses to the 54 Likert items on the Survey of Multiculturalism in Science Classrooms (SMSC). The second sub-question compared the percentage agreement data with the Likert items for all respondents, as well as for the four content area groups. This analysis continued looking at all 54 items from the SMSC and results are reported in terms of the five factors that items loaded with in the factor analysis. The third sub question used the technique of correlation matrix analysis to examine how responses to the Likert items correlated with each other. This analysis was performed for the 18 items in Factor 1 (Teachers' Beliefs and Attitudes on Multiculturalism) as that was the Factor whose items most aligned with this study's focus on the beliefs and attitudes of science teachers.

The SMSC contained 54 Likert based questions with the response choices: Strongly Agree, Agree, Somewhat Agree, Neutral, Somewhat Disagree, Disagree, and Strongly Disagree. For purposes of analysis using the SPSS Statistical package, the responses were coded from one to seven, with one representing Strongly Disagree and seven representing Strongly Agree. All statistical calculations were made with the seven degrees of response separated out; however, for ease of the reader, when reporting Likert results for specific questions the agreement and disagreement levels were compressed to create three levels (agree, neutral, disagree) instead of all seven levels. Due to the ordinal nature of data the traditional comparative ANOVA and parametric, paired t-tests could not be implemented in this study and the respectively comparable non-parametric Kruskal-Wallis (K-W) and Mann-Whitney U (MWU) tests were performed in stepwise progression instead.

K-W testing was applied to each of the 54 items from the survey in order to determine if there existed any statistical differences existed when comparing the responses of the four groups that represented the content area specialties of teachers (i.e. biology, chemistry, physics, and Earth science). For items where statistical differences were found between two or more groups, a stepwise application of MWU testing was applied for all paired combinations among the four content specialties to determine which pairs of groups demonstrated statistical differences. The percentage data for those questions were then reviewed to determine the directionality of the differences (i.e. which of the content area groups had more or less percentage agreement with the particular item).

4.2 Research Question 1a

The purpose of this question (Are there existing differences in the beliefs and attitudes of secondary science teachers of different content specialties (i.e., biology, chemistry, physics, and Earth science) in regards to working with students of multicultural backgrounds in secondary science classroom settings?) was to examine if there were statistically significant differences in the responses of science teachers certified in different content areas to the 54 Likert items on the Survey on Multiculturalism in the Science Classroom (SMSC). K-W testing of the Likert items indicated a general agreement among science teachers of the four content specialties in their beliefs and attitudes on multiculturalism and working with students of multicultural backgrounds. There were only five of the 54 items showing statistically significant differences among the content area groups. Of the five items, three of the items were from Factor 1, which specifically addressed Teachers' Beliefs and Attitudes on Multiculturalism. The following sections present the survey items grouped according to their distribution among the five factors that were identified through the factor analysis, with reporting of results only for those items that demonstrated a statistical difference during K-W testing.

Factor 1 (Teachers' Beliefs and Attitudes on Multiculturalism)

K-W testing of the items in Factor 1 indicated significant statistical differences in the responses of the four content specialty groups for three of the 18 Likert items that reported on teachers' personal and professional beliefs on multiculturalism and working with students of multicultural backgrounds in the science classroom.

Item 5 (*Everyone should be knowledgeable about the practices of other cultures*). K-W testing showed significant differences in the responses of teachers of different content areas to Item 5 (Everyone should be knowledgeable about the practices of others; K-W chi-square = 8.0, p = 0.05, df = 3, with mean rank scores of biology 75.7, chemistry 68.8, physics 97.2, and Earth science 69.3). Pairwise MWU comparisons of the responses of different content specialties demonstrated three pairings that had significant statistical differences. All three parings represented differences in responses of physics teachers to those of the other content areas: biology teachers (MWU = 521.5, $n_{(physics)} = 22$, $n_{(biology)} = 66$, $p < .03$ two-tailed), chemistry teachers (MWU = 302.0, $n_{(physics)} = 22$, $n_{(chemistry)} = 44$, $p < .007$ two-tailed), and Earth science teachers (MWU = 129.5, $n_{(physics)} = 22$, $n_{(Earth\ science)} = 19$, $p < .02$ two-tailed). Table 4.1 presents the responses of teachers to Item 5 (Everyone should be knowledgeable about the practices of other cultures).

Table 4.1

Survey Reponses to Item 5: Everyone Should Be Knowledgeable About the Practices of Other Cultures.

Content specialty of teachers	n	Agree (%)	Neutral (%)	Disagree (%)
All teachers	151	94.0	2.7	3.1
Biology	66	93.9	4.5	1.5
Chemistry	44	95.5	0	4.5
Physics	22	95.5	0	4.5
Earth science	19	84.2	5.3	10.5

The statistical differences from the MWU do not readily appear in the data due to the practice of grouping all three agreement and all three disagreement ratings together. For purposes of comparison, the responses to Item 5 are represented at finer grain in Table 4.2 and reveals that the differences found in the MWU tests were the result of the high percentage of physics teachers who strongly agreed with the statement.

Table 4.2

Survey Reponses to Item 5: Everyone Should Be Knowledgeable About the Practices of Other Cultures (with Agreement and Disagreement Levels Ungrouped).

Content specialty of teachers	n	StrA (%)	Agree (%)	SwA (%)	Neutral (%)	SwD (%)	Disagree (%)	StrD (%)
All teachers	151	33.1	48.3	12.6	2.7	2.0	0.0	1.3
Biology	66	33.3	47.0	13.6	4.6	0.0	0.0	1.5
Chemistry	44	22.7	56.8	15.9	0.0	2.3	0	2.3
Physics	22	63.7	22.7	9.0	0.0	4.6	0.0	0.0
Earth science	19	21.1	46.9	16.2	5.3	5.3	5.3	0.0

StrA= Strongly Agree; SwA = Somewhat Agree; SwD= Somewhat Disagree; StrD = Strongly Disagree

***Item 11 (*It is important to identify the cultural backgrounds of the students in my classes).** K-W testing showed significant differences in the responses of teachers of different content areas to Item 11 (It is important to identify the cultural backgrounds of the students in my classes; K-W chi-square = 8.0, $p = 0.05$, $df = 3$, with mean rank scores of biology 79.0, chemistry 65.3, physics 61.8, and Earth science 87.9). Pairwise MWU comparisons of the responses of different content specialties demonstrated two pairings that had significant statistical differences. Both parings represented differences in responses of physics teachers to those of the other content areas: biology teachers (MWU = 1080.5, $n_{(physics)} = 21$, $n_{(biology)} = 64$, $p < .04$ two-tailed), and Earth science teachers (MWU = 299.0, $n_{(physics)} = 21$, $n_{(Earth\ science)} = 17$, $p < .02$ two-tailed). Table 4.3 represents the responses of teachers to Item 11.

Table 4.3

Survey Responses to Item 11: It is Important to Identify the Cultural Backgrounds of the Students in My Classes.

Content specialty of teachers	n	Agree (%)	Neutral (%)	Disagree (%)
All teachers	146	73.3	11.0	15.8
Biology	64	78.1	6.3	15.6
Chemistry	44	64.7	23.5	11.8
Physics	21	63.6	15.9	20.5
Earth science	17	85.7	4.8	9.5

The statistical differences from the MWU testing appear to stem from the lower agreement of physics teachers with the need to identify cultural backgrounds. Whereas chemistry teachers had a similar overall agreement, the percentage of teachers disagreeing with the statement was more in line with the percentages for teachers of biology and physics.

***Item 18 (*The cultural background of a teacher has an impact on students).** K-W testing showed significant differences in the responses of teachers of different content areas to Item 18 (The cultural background of a teacher has an impact on students; K-W chi-square = 15.2, $p = 0.002$, $df = 3$, with mean rank scores of biology 72.3, chemistry 58.3, physics 92.4, and Earth science 93.9). Pairwise MWU comparisons of the responses of different content specialties demonstrated four pairings that had significant statistical differences. The responses of biology teachers differed statistically from those of both physics teachers (MWU = 485.0, $n_{(biology)} = 64$, $n_{(physics)} = 21$, $p < .05$ two-tailed), and Earth science teaches (MWU = 379.0, $n_{(biology)} = 64$, $n_{(Earth\ science)} = 17$, $p < .04$ two-tailed). The responses of chemistry teachers also differed statistically from those of both physics teachers (MWU = 258.0, $n_{(chemistry)} = 44$, $n_{(physics)} = 21$, $p < .003$ two-tailed), and Earth science teaches (MWU = 187.0, $n_{(chemistry)} = 44$, $n_{(Earth\ science)} = 17$, $p < .002$ two-tailed). The pair wise comparisons indicate similarities in how biology and chemistry teachers responded, similarities in how physics and Earth science teachers responded, and differences in the responses when comparing the two pairs of groups. There was a greater degree of significance in the differences of the responses of chemistry teachers in comparison to those to biology. Review of the Likert responses, as presented in Table 4.4, indicates that biology and chemistry teachers were less likely to agree with the statement, with chemistry teaches having the lowest agreement.

Table 4.4

Survey Responses to Item 18: The Cultural Background of a Teacher Has an Impact on Students.

Content specialty of teachers	N	Agree (%)	Neutral (%)	Disagree (%)
All teachers	142	87.7	8.2	4.1
Biology	64	87.5	9.4	3.1
Chemistry	44	84.1	9.1	6.8
Physics	22	90.5	4.8	4.8
Earth science	17	94.1	5.9	0

Factor 2 (Cultural Norms in Curriculum and Instruction)

K-W testing of the items in Factor 2 did not indicate significant statistical differences in the responses of the four content specialty groups for the 11 Likert items related to cultural norms and instruction.

Factor 3 (Challenges of Working in Settings with Students of Multicultural Backgrounds)

K-W testing of the items in Factor 3 did not indicate significant statistical differences in the responses of the four content specialty groups for the 12 Likert items related to challenges and concerns in working with students of multicultural backgrounds.

Factor 4 (Instructional Practices)

Of the eight items in Factor 4 that measured teacher beliefs and attitudes regarding their instructional practices when working with multicultural students, K-W testing showed significant differences in the responses of teachers of different content areas for only one item.

Item 48 **(A student's cultural background correlates to performance class).** K-W testing showed significant differences in the responses of teachers of different content areas to Item 48 (A student's cultural background correlates to performance in class; K-W chi-square = 7.7, $p = 0.05$, $df = 3$, with mean rank scores of biology 67.8, chemistry 72.1, physics 96.5, and Earth science 74.6). Pairwise MWU comparisons of the responses of different content specialties demonstrated two pairings -- both with physics teachers -- that had significant statistical differences. The responses of physics teachers differed statistically from those of both biology teachers (MWU = 406.5, $n_{(physics)} = 21$, $n_{(biology)} = 64$, $p < .005$ two-tailed), and chemistry teachers (MWU = 311.5, $n_{(physics)} = 21$, $n_{(chemistry)} = 44$, $p < .03$ two-tailed). A review of the responses to the statement, (Table 4.5), indicates that physics teachers had a higher percentage of agreement with the statement than teachers of the other content areas.

Table 4.5

Survey Responses to Item 48: A Student's Cultural Background Correlates to Performance in Class.

Content specialty of teachers	n	Agree (%)	Neutral (%)	Disagree (%)
All teachers	147	50.3	20.4	29.3
Biology	64	46.9	20.3	32.8
Chemistry	44	45.5	27.3	27.3
Physics	21	71.4	9.5	19.0
Earth science	18	50.0	16.7	33.3

Factor 5 (Teacher Preparation)

Of the five items in Factor 5 that measured teacher beliefs and attitudes regarding their preparation for working with multicultural students, K-W testing showed significant differences in the responses of teachers of different content areas for only one item

***Item 53 (*Only schools serving multicultural students need a racially, ethnically, and culturally diverse faculty).** K-W testing showed significant differences in the responses of teachers of different content areas to Item 53 (Only schools serving multicultural students need a racially, ethnically, and culturally diverse faculty; K-W chi-square = 10.4, p = 0.02, df = 3, with mean rank scores of biology 75.8, chemistry 86.8, physics 54.3, and Earth science 67.6). Pairwise MWU comparisons of the responses of different content specialties demonstrated two pairings -- both with physics teachers -- that had significant statistical differences. The responses of physics teachers statistically differed from those of both biology teachers (MWU = 493.5, $n_{(physics)} = 21$, $n_{(biology)} = 66$, $p < .03$ two-tailed), and chemistry teaches (MWU = 262.5, $n_{(physics)}$ =

21, $n_{(chemistry)} = 44$, $p < .002$ two-tailed). Examination of the responses to the question, as represented in Table 4.6, indicates that physics teachers were the only group to show unanimous disagreement with the statement, while the samples of biology and chemistry teachers had a greater percentage of agreement or neutrality to the statement than Earth science teachers.

Table 4.6

Survey Responses to Item 53: Only Schools Serving Multicultural Students Need a Racially, Ethnically, and Culturally Diverse Faculty.

Content specialty of teachers	N	Agree (%)	Neutral (%)	Disagree (%)
All teachers	149	7.4	4.7	87.9
Biology	66	6.1	7.6	86.4
Chemistry	44	13.6	4.5	81.8
Physics	21	0	0	100
Earth science	18	5.6	0	94.4

4.3 Research Question 1b

The purpose of this sub-question (What are the patterns of correlations among the responses to the Likert-scale items for all respondents and for each of the content specializations (i.e., biology, chemistry, physics, and Earth science) regarding personal and professional beliefs on multiculturalism in the science classroom?) was to examine how the responses of the different content area groups compared in terms of correlation between the 18 items in Factor 1 (Teachers' Beliefs and Attitudes on Multiculturalism).

Factor 1 addressed the overall respondents' professional and personal beliefs on multiculturalism that represented a holistic set of perspectives on their personal role as a teacher. In comparison, the other factors focused more on professional strategies of classroom practice. To focus on the similarities and differences of the beliefs between the different content specialties within science, and to make comparisons to the beliefs of science teachers overall, the correlation network analyses are presented below. These are focused on the 18 items in Factor 1, as listed in Table 4.7.

In the correlation network diagrams, a node (appearing as a box containing a label) represents a Likert item in the network that is connected to one or more other items by linkages (interconnecting line). Each linkage represents a correlation of 0.7 or higher between the two items, as explained in the Methods Chapter. A central node is typically one that has the greatest number of linkages making it largely anchored within the surrounding linked nodes. Peripheral nodes are connected to the network with a single linkage. Items that had no linkages to other items have been removed from the diagrams as is customary for this method of analysis.

The ratio of linkages to nodes is an indicator of the coherence of linked nodes within the network; the higher the ratio the more coherently the nodes are interlinked with one another. The saturation of the network represents the percentage of linkages relative to all possible linkages that could have occurred for the given number of nodes in the network (with the criterion of $r = 0.7$). For example, if a network has a total of 10 linkages, but the total number of possible linkages with all nodes fully connected is 15, then the saturation expressed as a percentage would be $(10/15) \times 100 = 67\%$.

For the reader's convenience, nodes are referred to by Likert item number as listed in Table 4.7. The 18 items were used as appropriate in constructing the correlation network diagrams, although only a portion of the items actually appear in the diagrams presented in this chapter. As is customary for this method of analysis, items that had no linkages to other items have been removed from the diagrams.

Overview of correlation network analysis.

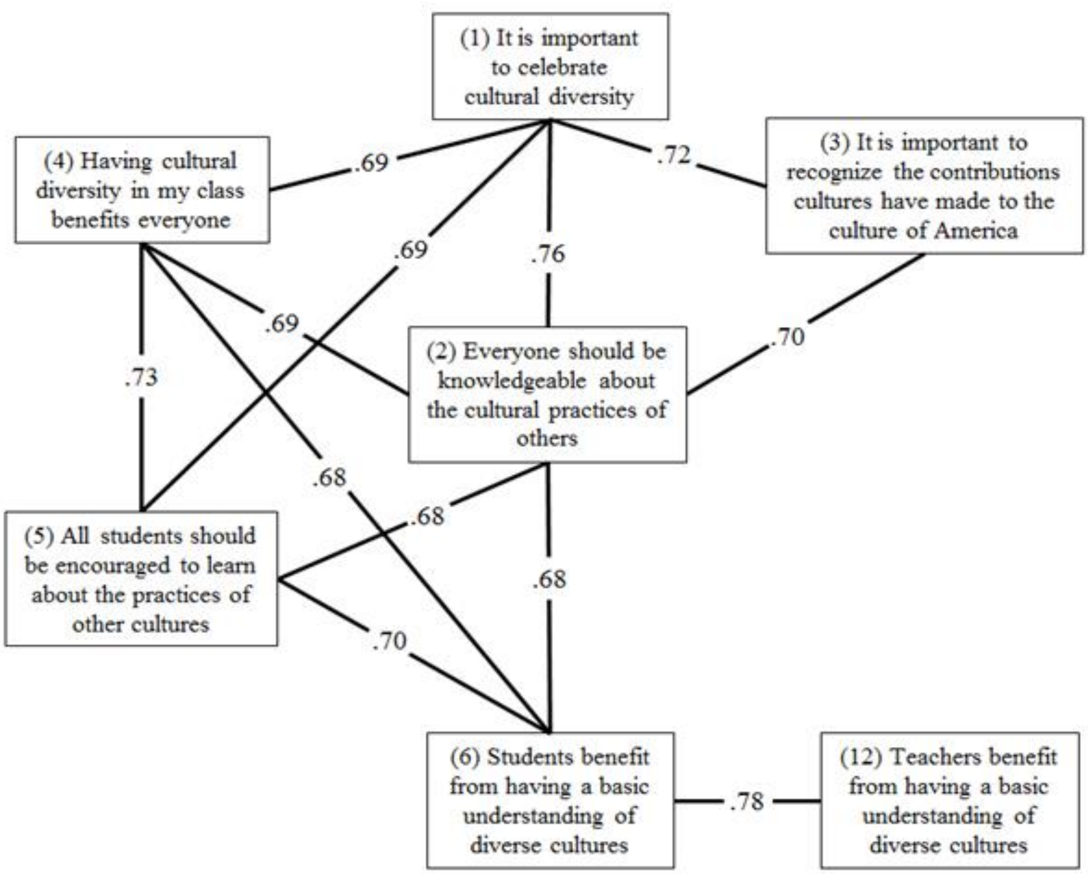
Correlation network analysis of the responses of the four content area specialty groups for Factor 1 (Teachers' Beliefs and Attitudes on Multiculturalism) indicated that the correlation matrices for biology and Earth science teachers were comparable. Both diagrams had eight nodes with Node 4 (Having cultural diversity in my classroom benefits everyone) representing the central node for both. Chemistry and physics teachers showed similarities in their network diagrams. With 13 nodes, the responses of chemistry teachers represented a richer network of connections in comparison to biology and Earth science teachers. Physics teachers represented the richest network of connections with 17 of the possible 18 nodes represented. Node 2 (Everyone should be knowledgeable about the cultural practices of others) and Node 6 (Students benefit from having a basic understanding of diverse cultures) represented the central or secondary major node for chemistry. An examination of the nodes present in the diagrams also indicated that the items present in the correlation networks for biology and Earth science teachers predominantly represented internal beliefs and that the items most closely associated with attitudes, and the implementation of actions, were not present. In comparison the correlation networks of physics and chemistry teachers included items that represented both beliefs and attitudes.

Total Respondents.

The correlation network diagram for total respondents (Fig. 4.1) contains seven nodes and 12 linkages. Only Items 1 through 6 and Item 12 had pairwise correlations that met the threshold r = 0.7 and were therefore the only items included as nodes in this network.

Figure 4.1

Total sample correlation network diagram for Teachers' Personal and Professional Beliefs on Multiculturalism (n = 152).



The correlation values, inserted along each of the linkages, ranged from 0.68 to 0.78. Node 2 with the most linkages (five) was also the central node in this network diagram and clearly anchored the other surrounding nodes. Nodes 1, 4, 5, and 6 each had four linkages, Node 3 had two linkages, and Node 12, which had only one linkage, was classified as a peripheral node. Overall, the nodes were rather rich in linkages. The proportion of linkages to nodes was 1.71, and the total possible number of linkages when all nodes were fully connected (saturation) was 21; thus, the network had a saturation of 57%. There were nine linkages in total between pairs of nodes in the densely-linked group comprised of Nodes 1, 2, 4, 5, and 6. These nodes form a cluster based on the multiple linkages among them, and all reflect beliefs on general importance of celebrating cultural diversity and the importance of cultural diversity for the benefit of students.

Content specialties of teachers.

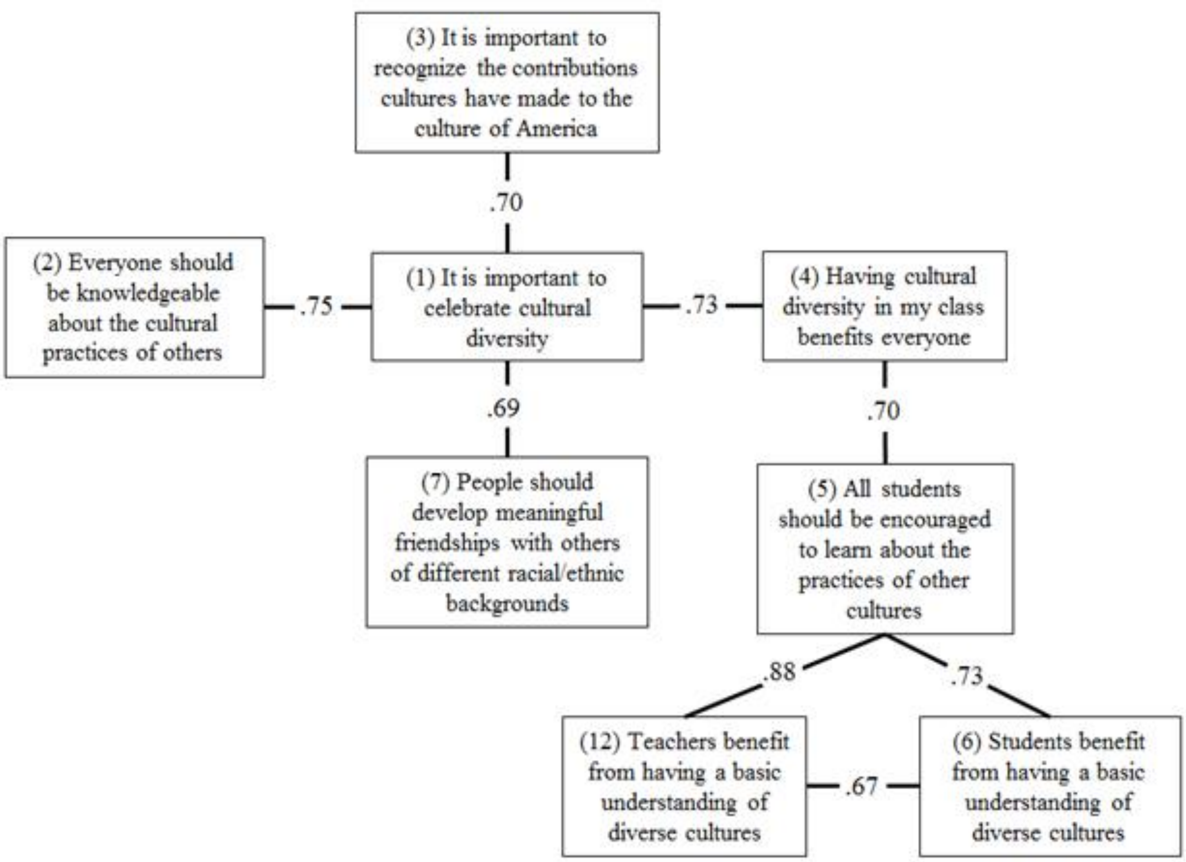
The sections below present correlation network diagrams constructed for the items in Factor 1 for each of the disciplines identified in this study.

Biology respondents. The correlation network diagram biology teachers (Fig. 4.2) contains eight nodes and eight linkages. Only Items 1 through 7 and Item 12 had pairwise correlations that met the threshold r = 0.7 and were therefore the only items included as nodes in this network. The correlation values, inserted along each of the linkages, ranged from 0.67 to 0.88. Node 1 with the most linkages (four) was a major node and was also the central node in this network diagram. Node 5 had three linkages, Nodes 4, 6, and 12 and all had two linkages. Nodes 2, 3, and 7, which all had only one linkage, were classified as peripheral nodes. The proportion of linkages to nodes was 1.00 (i.e. one linkage on average between each pair of nodes), and the total possible number of linkages when all nodes were fully connected 28; thus, the network had a saturation of 29%.

The diagram structure indicates two clusters of items. One cluster was situated around Node 1 which was connected to Nodes 2, 3, 4, and 7. This cluster had a common theme of recognizing and celebrating the importance of cultural diversity. The second cluster involves Nodes 5, 6, and 12, with Node 5 as the link to the overall network. This cluster had a common theme of stakeholders benefiting from being in a culturally diverse environment.

Figure 4.2

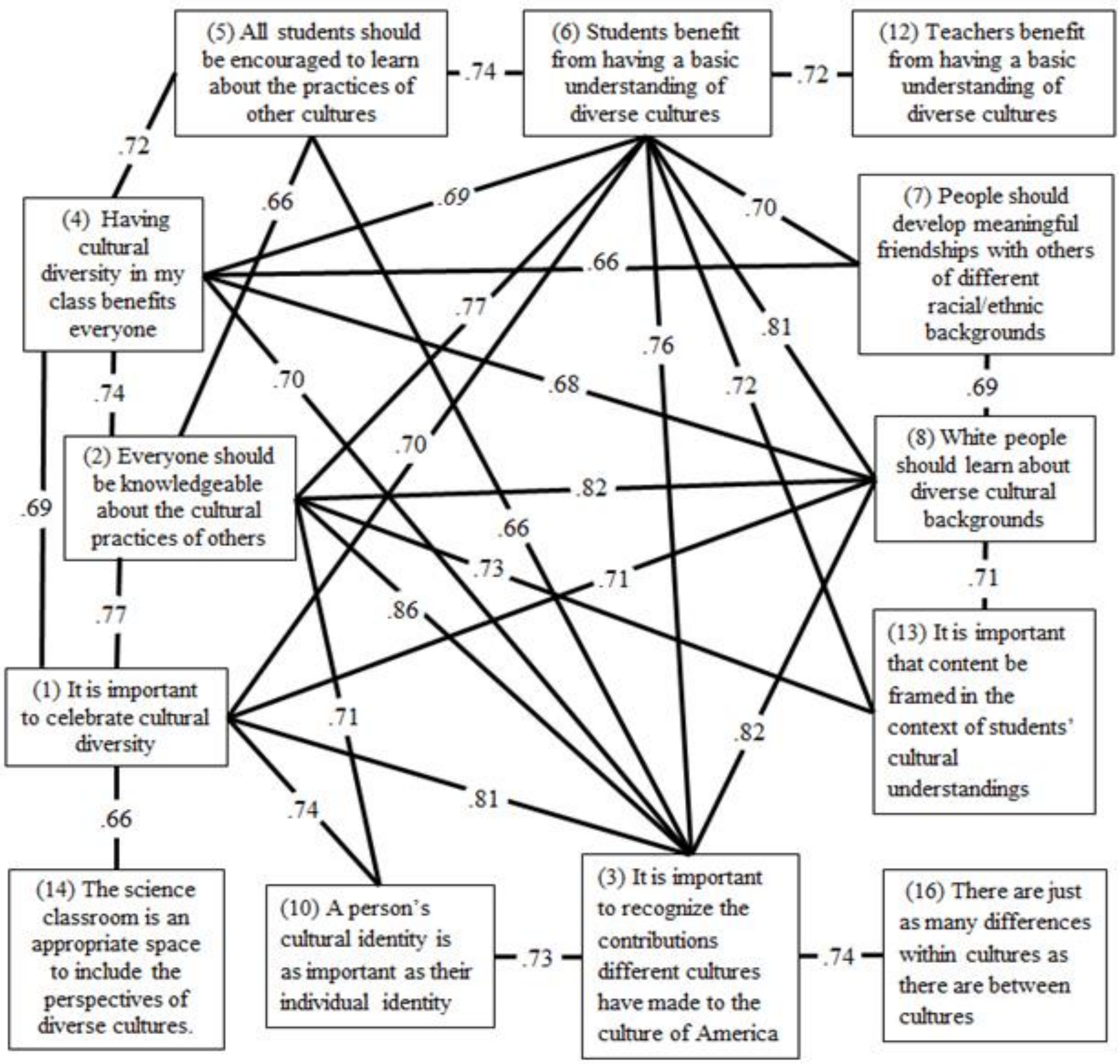
Biology Teacher's Correlation Network Diagram for Teachers' Personal and Professional Beliefs on Multiculturalism (n = 92).



Chemistry respondents. The correlation network diagram for chemistry teachers (Fig. 4.3) contains 13 nodes (Items 1-8, and 10, 12, 13, 14, and 16) and 31 linkages. The correlation values, inserted along each of the linkages, ranged from 0.66 to 0.82.

Figure 4.3

Chemistry teacher correlation network diagram for Teachers' Personal and Professional Beliefs on Multiculturalism (n = 44).

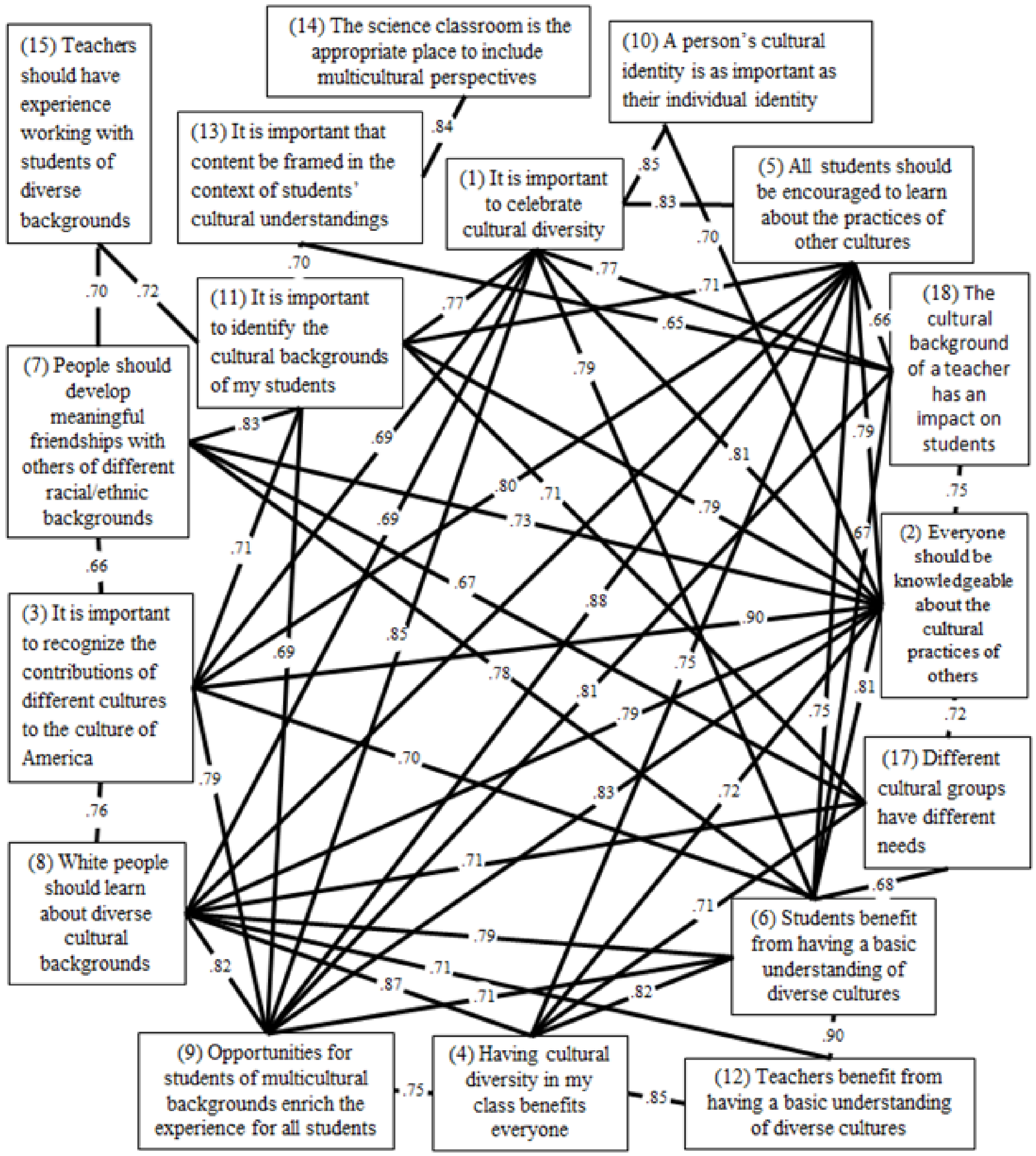


The six major nodes in the diagram, in order of descending number of linkages were: Node 6 (nine linkages), Node 2 (eight linkages), Node 3 (eight linkages), Node 1 (seven linkages), Node 4 (seven linkages), and Node 8 (seven linkages). With 15 linkages and six nodes, these six nodes formed a rich network of connections (100% linkage saturation) where all possible linkages had been realized within this subset. There were an additional four minor nodes: Node 5 (four linkages), Node 7 (three linkages), Node 10 (three linkages), and Node 13 (three linkages). These four minor nodes had linkages to Node 6, with either two or three linkages to the other major nodes. Nodes 12, 14, and 16, which all had only one linkage to a node within the central network, were classified as peripheral nodes. The diagram structure indicates a richness of connections within the six major nodes, sharing two common themes: 1) the benefits of cultural diversity in a classroom and 2) the need for being knowledgeable about diverse cultural backgrounds. For the entire network, the proportion of linkages to nodes was 2.38, and the network had a saturation of 40%.

Physics respondents. The correlation network diagram for physics teachers (Fig. 4.4) contains 17 nodes (Items 1 -15, 17, and 18) and 56 linkages. The correlation values, inserted along each of the linkages, ranged from 0.65 to 0.90. There are seven major nodes in the diagram that connect to at least half of the other items: Node 2 (12 linkages), Node 6 (11 linkages), Nodes 1, 5, 8, 9, and 11 (nine linkages each). With 19 linkages between these seven nodes, there was a rich network of connections with 90% linkage saturation accounting for a third of the linkages in the entire diagram. There were an additional nine minor nodes: Node 3 (eight linkages), Node 4 (seven linkages linkages); Nodes 7, 17 and 18 (six linkages each); Nodes 12 and 13 (three linkages each); and Nodes 10 and 15 (two linkages each). All nine minor nodes had linkages to at least one of the major nodes.

Figure 4.4

Physics Teachers' Correlation Network Diagram for Teachers' Personal and Professional Beliefs on Multiculturalism (n = 22).

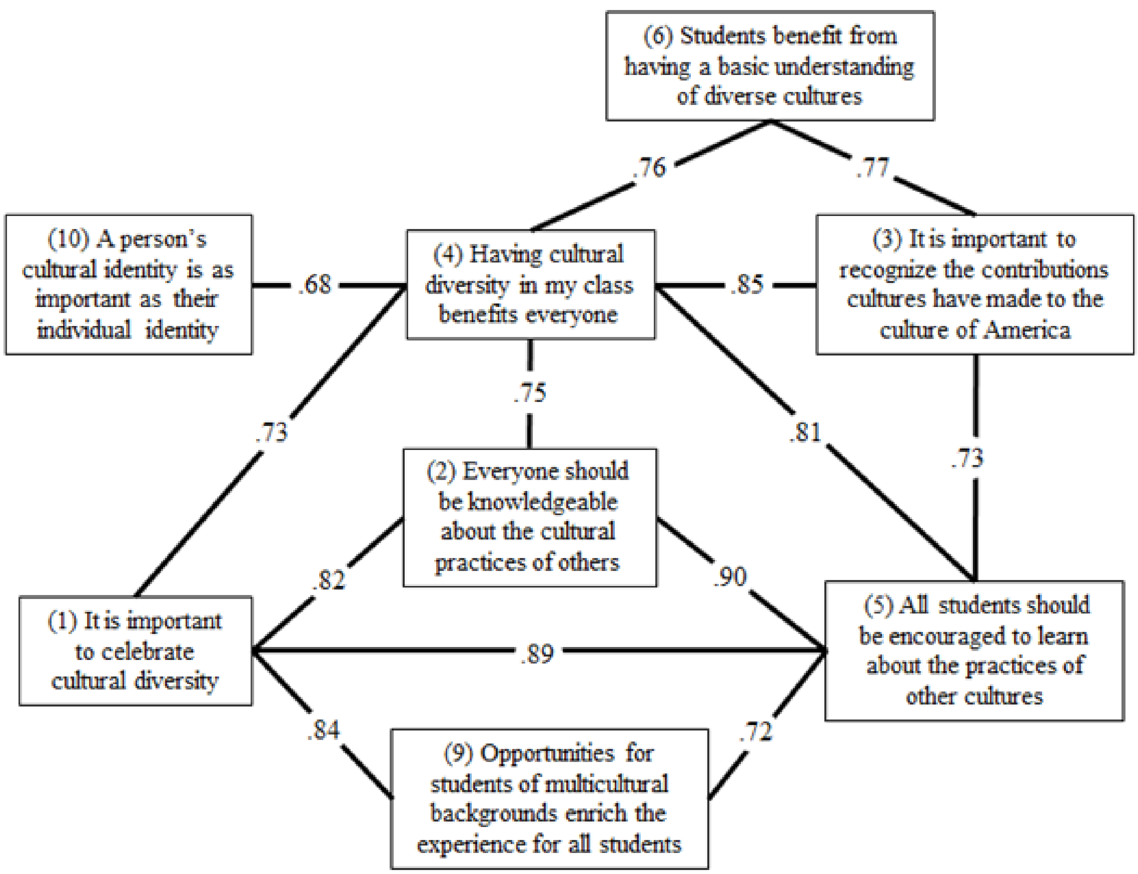


Node 14 was classified as a peripheral node because it had only one linkage to Item 13, which was also a minor node within the network. For the entire network, the proportion of linkages to nodes was 3.29, and the network had a saturation of 41%.

Earth science respondents. The correlation network diagram for Earth science teachers (Fig. 4.5) contains eight nodes (Items 1-6, 9, and 10), and 13 linkages.

Figure 4.5

Earth Science Teachers' Correlation Network Diagram for Teachers' Personal and Professional Beliefs on Multiculturalism (n = 19).



The correlation values, inserted along each of the linkages, ranged from 0.67 to 0.90. Node 4 with the most linkages (six) was a major node and was also the central node in this network diagram. Node 5 had five linkages, Node 1 had four linkages, Nodes 2 and 3 had three linkages, Nodes 6 and 9 had two linkages, and Node 10 was a peripheral node. The proportion of linkages to nodes was 1.63, and the network had a saturation of 46%.

4.4 Research Question 1c

The purpose of this sub-question (What are the patterns of responses to the Likert items for the entire sample of respondents and for those in each of the content specializations [biology, chemistry, Earth science, and physics] in relation to their beliefs and attitudes towards working with multicultural students in science classrooms?) was to compare the Likert item responses of the different content area groups based on their percentage agreement with the specific items. The analysis is presented with items grouped according to the five factors, with an examination of the results for all teachers, followed by the results of the content area groups, and an overview of the findings for the factor.

For the convenience of the reader, the tables of results presented in this section have been organized by factor and include only a tabulation of the percent of responses for each Likert item that was in the agreement range by all respondents. These tables also include the teacher responses for the four sub-groupings of the data among the content specialties of the teachers (biology, chemistry, physics, and Earth science). Tables containing the complete response data for all Likert survey items (i.e., agreement, neutral responses, and disagreement) can be found in Appendix E (total sample of teachers), Appendix F (biology teachers), Appendix G (chemistry teachers), Appendix H (physics teachers), and Appendix I (Earth science teachers).

The analysis reported in these sections is based on teacher responses to the 18 Likert items identified as relating to the professional and personal beliefs that science teachers have regarding working with students of multicultural backgrounds. The main findings for the section are presented first followed by more in depth analysis of the results of the study, with findings reported for the Total sample of teachers; followed by analysis of data for each of the Content specialties of teachers: biology, chemistry, physics, and Earth sciences; and ending with Comparisons of responses to each of the factors (1-5).

Factor 1 (Teachers' Beliefs and Attitudes on Multiculturalism)

On the whole teachers agreed with the 18 statements from Factor 1, though a distinction could be made for the levels of agreement for items that reflected beliefs and items that reflected attitudes. Across the board all groups demonstrated high agreement with statements that reflected the internal beliefs that teachers hold about the importance of multiculturalism with statements such as Item 1 (It is important to celebrate cultural diversity), Item 3 (It is important to recognize the contributions different cultures have made to the culture of the United States), Item 6 (Students benefit from having a basic understanding of diverse cultures), and Item 12 (Teachers benefit from having a basic understanding of diverse cultures).

The items of least agreement reflected teacher attitudes and aligned more with their behavioral expressions and instructional practices. All disciplinary groups had comparatively lower agreement with Item 11 (It is important to identify the cultural backgrounds of my students), Item13 (It is important that content be framed in the context of students' cultural understandings), Item 14 (The science classroom is an appropriate space to include multicultural perspectives), and Item 15 (Teachers should have experience working with students of diverse backgrounds). When comparing the responses of the different disciplinary groups, chemistry teachers showed less agreement with these items in comparison with similar levels of agreement as expressed by Earth science teachers with Item 11 and Item 14, and noticeably lower agreement than all other teachers with Item 13.

Total sample of teachers. The percentage of agreement for the total sample of teachers for each of the Likert items in Factor 1 is presented in Table 4.7. As noted above, complete representation of responses to the Likert items for Factor 1 is presented Appendix E.

For all 18 Likert items related to the beliefs and attitudes of science teachers on multiculturalism, most responses were in the agreement categories (i.e. Strongly Agree, Agree, and Somewhat Agree). Eleven items showed higher than 90% agreement by the respondents. Five items had agreement responses within the range of 80% and 90% of respondents. Two items had responses of agreement in the 70% to 80% range. There were no items with agreement below 70%. The three items with the highest agreement among respondents were 98.7% agreement with Item 6 (Students benefit from having a basic understanding of diverse cultures), 98.7% agreement with Item 12 (Teachers benefit from having a basic understanding of diverse cultures), and 96.0% agreement with Item 3 (It is important to recognize the contributions different cultures have made to the culture of America). The three items with lowest agreement from respondents were 80.4% agreement with Item 14 (The science classroom is an appropriate space to include multicultural perspectives), 73.3% agreement with Item 1 (It is important to identify the cultural backgrounds of my students), and 70.6% agreement with Item 13 (It is important that content be framed in the context of students' cultural understandings).

***Content specialties of teachers*.** The sections below, and Table 4.7, present data on respondent agreement with the Likert items based on the content specialty. Complete description of the data can be found in the appendices.

Table 4.7

Percentage Agreement with Likert Items Pertaining to Factor 1: Teachers' Beliefs and Attitudes on Multiculturalism

Abbreviated items	Percentage agreement				
	Total (n=152)	Biology (n=67)	Chemistry (n=44)	Physics (n=22)	Earth sci (n=19)
1. It is important to celebrate cultural diversity.	92.1	93.9	93.2	90.9	84.2
2. Everyone should be knowledgeable about the cultural practices of others.	94.0	93.9	95.5	95.5	89.5
3. It is important to recognize the contributions different cultures have made to the culture of the United States.	96.0	97.0	95.4	95.5	94.7
4. Having cultural diversity in my class benefits everyone.	91.0	93.8	88.4	85.7	94.1
5. All students should be encouraged to learn about the practices of other cultures.	95.3	98.5	93.2	95.2	88.9
6. Students benefit from having a basic understanding of diverse cultures.	98.7	100.0	95.5	100.0	100.0
7. People should develop meaningful friendships with people of different racial/ethnic groups.	91.3	92.4	90.9	90.5	89.5
8. White people should learn about diverse cultural backgrounds.	94.0	95.5	93.2	90.5	94.4
9. Opportunities for students of multicultural backgrounds enrich the experience for all students.	93.8	95.3	88.6	95.2	100.00
10. A person's cultural identity is as important as their individual identity.	82.8	81.8	84.1	77.3	89.5
11. It is important to identify the cultural backgrounds of my students.	73.3	78.1	64.7	63.6	85.7
12. Teachers benefit from having a basic understanding of diverse cultures.	98.7	98.5	97.7	100.0	100.0

Table 4.7 (continued)

Percentage Agreement with Likert Items Pertaining to Factor 1: Teachers' Beliefs and Attitudes on Multiculturalism

Abbreviated items	Percentage agreement				
	Total (n=152)	Biology (n=67)	Chemistry (n=44)	Physics (n=22)	Earth sci (n=19)
13. It is important that content be framed in the context of students' cultural understandings.	70.6	78.1	54.6	76.2	76.5
14. The science classroom is an appropriate space to include multicultural perspectives.	80.4	89.2	70.5	81.0	72.2
15. Teachers should have experience working with students of diverse backgrounds.	80.8	81.3	77.3	81.0	88.2
16. There are just as many differences within cultures as there are between cultures.	92.1	90.9	88.6	95.5	100.0
17. Different cultural groups have different needs.	89.5	91.0	88.6	81.8	94.7
18. The cultural background of a teacher has an impact on students.	87.7	87.5	84.1	90.5	94.1

Biology teachers. The percentage of agreement of responses for biology teachers for the items related to their personal and professional beliefs on multiculturalism was in the range of 78.1% to 100%. Twelve items (Items 1 through 9, 12, 16 and 17) showed higher than 90% agreement by the respondents. Four items (Items 10, 14, 18, and 15) had between 80% and 90% agreement. The remaining two items (Items 11 and 13) had between 70% and 80% agreement. The three items that biology teachers had most agreement with were: Item 6 (Students benefit from having a basic understanding of diverse cultures), which had 100% agreement, Item 12 (Teachers benefit from having a basic understanding of diverse cultures), which had 98.5% agreement, and Item 5 (All students should be encouraged to learn about the practices of other cultures), which had 97.0% agreement. The three items that biology teachers showed least agreement with were: Item 15 (Teachers should have experience working with students of diverse backgrounds), which had 81.3% agreement, Item 11 (It is important to identify the cultural backgrounds of my students), and Item13 (It is important that content be framed in the context of students' cultural understandings) with both having 78.1% agreement.

Chemistry teachers. The percentage of agreement of responses by chemistry teachers for the items related to their personal and professional beliefs on multiculturalism was in the range of 54.1% to 97.7%. Eight items (Items 1, 2, 3, 5, 6, 7, 8, and 12) showed higher than 90% agreement by the respondents. Six items (Items 4, 9, 10, 16, 17, and 18) had between 80% and 90% agreement. Two items (Items 14 and 15) had between 70% and 80% agreement. One item (Item 11) had between 60% and 70% agreement, and the remaining one item (Item 13) had between 50% and 60% agreement. The three items that chemistry teachers showed most agreement with were: Item 12 (Teachers benefit from having a basic understanding of diverse cultures), which had 97.7% agreement, Item 6 (Students benefit from having a basic understanding of diverse cultures), which had 95.5% agreement, and Item 2 (Everyone should be knowledgeable about the cultural practices of others), which had 95.5% agreement. The three items that chemistry teachers showed least agreement with were: Item14 (The science classroom is the appropriate space to include multicultural perspectives), which had 70.5% agreement, Item 11 (It is important to identify the cultural backgrounds of my students), which had 63.6% agreement and Item 13 (It is important that content be framed in the context of students' cultural understandings), which had 54.6% agreement.

Physics teachers. The percentage of agreement of responses for physics teachers for the items related to their personal and professional beliefs on multiculturalism was in the range of

76.2% to 100%. Eleven items (Items 1, 2, 3, 5 through 9, 12, 16 and 18) showed higher than 90% agreement by the respondents. Four items (Items 4, 14, 15, and 17) had between 80% and 90% agreement. Two items (Items 10 and 13) had between 70% and 80% agreement. The remaining item (Item 11) had less than 70% agreement. The three items that physics teachers showed most agreement with were: Item 12 (Teachers benefit from having a basic understanding of diverse cultures), which had 100% agreement, Item 6 (Students benefit from having a basic understanding of diverse cultures), which had 100% agreement, and Item 2 (Everyone should be knowledgeable about the cultural practices of others), which had 97.0% agreement. The three items that physics teachers showed least agreement with were: Item 10 (A person's cultural identity is as important as their individual identity), which had 77.3% agreement, Item 13 (It is important that content be framed in the context of students' cultural understandings), which had 76.2% agreement, and Item 11 (It is important to identify the cultural backgrounds of my students) which had 63.6% agreement.

Earth science teachers. The percentage of agreement of responses for Earth science teachers for the items related to their personal and professional beliefs on multiculturalism was in the range of 64.7% to 100%. Nine items (Items 3, 4, 6, 8, 9, 12, 16, 17, and 18) showed higher than 90% agreement by the respondents. Seven items (Items 1, 2, 5, 7, 10, 11, and 15) had between 80% and 90% agreement. The two remaining items (Items 13 and 14) had between 70% and 80% agreement. Earth science teachers showed 100% agreement with four items: Item 12 (Teachers benefit from having a basic understanding of diverse cultures), Item 6 (Students benefit from having a basic understanding of diverse cultures), Item 16 (There are just as many differences within cultures as there are between cultures) and Item 9 (Opportunities for students of multicultural backgrounds enrich the experience for all students). The two items that Earth science teachers showed least agreement with were: Item 13 (It is important that content be framed in the context of students' cultural understandings), which had 76.5% agreement, Item 14 (The science classroom is an appropriate space to include multicultural perspectives), which had 72.2% agreement.

Comparisons of responses to items in Factor 1. With respect to the total sample of teachers (n=152), items in Factor 1 represented ideas that teachers generally agreed with. For example, Item 6 (Students benefit from having a basic understanding of diverse cultures) and Item 12 (Teachers benefit from having a basic understanding of diverse cultures) both had 98.7% agreement among all teachers. The lowest percentage agreement for all teachers was 70.6% for Item 13 (It is important that content be framed in the context of students' cultural understandings). Much like Items 6, 12, and 13, other items with highest agreement generally represented global ideals and beliefs regarding multiculturalism, whereas the items that teachers had the least agreement with related to attitudes and the science classroom practices around instruction of multicultural students.

Comparing responses of teachers in different content specialties, some relevant comparative data are presented. Biology and physics teachers showed a tighter range of percentage agreement among the 18 items related to the personal and professional beliefs of multiculturalism in the classroom relative to the other disciplines, with agreement on the items ranging from 78.1% to 100% for biology teachers and 76.2% to 100% for Earth science teachers. The range of 64.7% to 100% agreement for Earth physics was slightly broader. Chemistry teachers, with a range of 54.6% to 97.7% had the broadest range of agreement for the items on the survey. These differences in ranges can be attributed to the relatively lower agreement that chemistry teachers and Earth science teachers had for Item 13 (It is important that content be framed in the context of students' cultural understandings) and Item 14 (It is important to identify the cultural backgrounds of my students) in comparison to the other content areas. Aligned to the findings for the total sample of teachers, the items with highest agreement across all four content specialty areas represented global ideals and beliefs about multiculturalism Item12 (Teachers benefit from having basic understandings of diverse cultures) had a range of agreement from 97.7% to 100% and Item 6 (Students benefit from having basic understandings of diverse cultures) had agreement ranging from 95.5% to 100%.

The items that teachers had the least agreement with were related to classroom practices around instruction that would focus on multicultural students. Item 13 (It is important that content be framed in the context of students' cultural understandings) was the lowest ranked item of agreement for biology (78.1%), chemistry (54.6%), and physics teachers (76.2%) and ranked third from last for Earth science teachers (76.5%), with a large difference in the percentage agreement for chemistry teachers in comparison to teachers of the other three subject areas. Moreover, Item 15 (Teachers should have experience working with students of diverse backgrounds) was within the bottom five responses of all four disciplines with percentage agreement of 81.3% for biology teachers, 77.3% for chemistry teachers, 81.0% for physics teachers, and 88.2% for Earth science teachers.

Item 14 (The science classroom is an appropriate space to include multicultural perspectives) had relatively low agreement, and ranked second from the bottom for Earth science teachers (72.2%), ranked third from the bottom for both chemistry teachers (70.5%) and physics teachers (81.0%), and fifth from the bottom for biology teachers (89.2%). This seems interesting in the context of the high levels of agreement that teachers had for Item 6 (Students benefit from having a basic understanding of diverse cultures) and Item 12 (Teachers benefit from having a basic understanding of diverse cultures).

Ten of the 18 items in Factor1 had ranges of 10% agreement or closer among the four groups of content teachers. The items of greatest consistency were Item 12 (Teachers benefit from having a basic understanding of diverse cultures) with a range of 97.7% agreement to 100% agreement and Item 3 (It is important to recognize the contributions different cultures have made to the culture of the United States) with a range of agreement from 94.7% to 97%. The item of least consistency between the different content areas was Item 13 (It is important that content be framed in the context of students' cultural understandings) with a range of 54.6% agreement among chemistry teachers to 78.1% agreement among biology teachers, with Earth science (76.5% agreement) and physics teachers (76.2% agreement) both being closer to biology teachers. The overall 23.5% range of agreement for Item 13 contracts to 1.9% when the responses of chemistry teachers were omitted. The responses of the chemistry teachers were removed to determine the effect of omitting the responses for the group of teachers with the lowest agreement level (54.6 %, chemistry teachers). No other items in Factor 1 had a range that changed by more than 10% by removing the content area with highest or lowest agreement. However, it is important to recognize that 54.6% doe represent a majority of chemistry teachers.

The second least consistent item was Item 11 (It is important to identify the cultural backgrounds of my students) with a range of 22.1% agreement (63.6% agreement among physics teachers compared to 85.7% agreement among Earth science teachers). However, there was no single content area with responses differing greatly from the other three with physics teachers (64.7% agreement) closer to chemistry teachers and biology teachers (78.1% agreement) being closer to the middle of the two extremes. Chemistry teachers had least agreement with the items, with the lowest agreement being highlighted by their difference from the other three content areas for Item 13.

Factor 2 (Cultural Norms in Curriculum and Instruction)

The analysis reported in this section is based on teacher responses to the 11 Likert items relating teacher beliefs on how cultural norms are represented in curriculum and instruction. The results of the responses to the Likert items for the total sample for Factor 2 are presented in Table 4.8.

Across all disciplines of science teachers there was a very strong agreement with the belief that cultural norms can advantage certain populations over others. There was consistently less agreement with the belief that the needs of multicultural students receive equal attention when compared to their White classmates and very low agreement with the belief that all students should be taught the same way, regardless of culture. Though there was overall low agreement with the belief that it is the student's responsibility to overcome barriers to success, physics teachers showed visibly higher agreement with the statement when compared to teachers of the other three disciplines.

***Total sample of teachers*.** Responses to the items in Factor 2 had a wider range of agreement than those in Factor 1; agreement with statements ranged from 7.5% to 97.3%, and less than 50% reported agreement for most items. The item that most teachers agreed (97.3%) was Item 22 (Cultural norms in America advantage certain populations over others). The item with least agreement (7.5%) was Item 25 (Only schools serving multicultural students need diverse staff and faculty). The next two items of lowest agreement were Item 20 (Multicultural backgrounds are adequately represented in most curricular materials) and Item 21 (All students should be taught the same way, regardless of cultural differences).

Table 4.8

Agreement with Likert Items Pertaining to Factor 2: Cultural Norms in Curriculum and Instruction

Abbreviated items	Percentage agreement				
	Total (n=152)	Biology (n=67)	Chemistry (n=44)	Physics (n=22)	Earth Sci (n=19)
19. Science curriculum reflects the contributions of many global cultures.	39.5	45.3	29.6	38.1	44.4
20. All students should be taught the same way, regardless of cultural differences.	15.7	20.6	11.4	9.5	17.7
21. Multicultural backgrounds are adequately represented in most curricular materials.	15.7	12.5	18.2	14.3	22.2
22. Cultural norms in America advantage certain populations over others.	97.3	97.0	95.5	100.0	100.0
23. Science curriculum generally reflects a modern Western / Eurocentric perspective.	81.6	76.6	86.4	81.0	88.9
24. It is difficult for people of multicultural backgrounds to become successful in America.	45.6	42.4	40.9	52.4	61.1
25. Only schools serving multicultural students need diverse staff and faculty.	7.5	6.3	13.6	0.0	5.9
26. It is the student's responsibility to make accommodations to overcome cultural barriers.	26.7	26.6	20.5	47.6	17.7
27. Cultural background should not impact performance because science is objective.	52.4	46.9	56.8	61.9	50.0
28. White students have more opportunities in mathematics and science than others.	41.8	39.1	41.9	47.6	44.4
29. Needs of multicultural students receive equal attention when compared to their White classmates.	66.9	64.1	74.4	61.9	64.7

Content specialties of teachers. The data for percentage agreement for these items are presented in Table 4.8, and a complete description of the data can be found in the appendices. Within each of the content specialty areas, the range of agreement for all items in Factor 2 was significantly wider than those for Factor 1. Physics teachers represented the widest range with agreement spanning from 100% for Item 22 to 0% for Item 25. Earth science teachers had a range of agreement spanning from 100% for Item 22 to 5.9% for Item 25. Biology teachers had a range of agreement spanning from 97.3% for Item 22 to 6.3% for Item 25. Chemistry teachers had the tightest range of agreement spanning from 95.5% for Item 22 to 11.4% for Item 20. The responses for teachers of the different specialties in science were generally consistent with the pattern presented in the sub-section for the total sample of teachers.

Total sample of teachers. Teachers of all four disciplines had the highest agreement and the tightest range of agreement in response to Item 22 (Cultural norms in America advantage certain populations over others), with agreement ranging from 95.5% to 100%. Although there was a drop in agreement across all disciplines, the second most agreed upon item was consistently Item 23 (Science curriculum generally reflects a modern Western / Eurocentric perspective), which had a wider range with 76.6% agreement among biology teachers and 88.9% agreement among Earth science teachers. And after another significant drop, Item 29 (Needs of multicultural students receive equal attention when compared to their White classmates) was consistently the third most agreed upon item with a range of 61.9% agreement among physics teachers to 74.4% agreement among chemistry teachers. Item 26 (It is the student's responsibility to make accommodations to overcome cultural barriers) had the widest range of agreement among groups with a range of 29.9% (47.6% agreement among physics teachers compared to 17.7% agreement among Earth science teachers), Although the order of agreement shifted between the responses of the teachers from the four disciplines, the three items of lowest agreement were consistently Item 20 (All students should be taught the same way, regardless of cultural differences) ranging from 9.5% agreement to 20.6% agreement; Item 21 (Multicultural backgrounds are adequately represented in most curricular materials) ranging from 12.5% agreement to 22.2% agreement, and Item 25 (Only schools serving multicultural students need diverse staff and faculty) ranging from 0% agreement to 13.6% agreement. The one exception was for Earth science teachers, where Item 21 was the fourth lowest item of agreement and Item 26 (It is the student's responsibility to make accommodations to overcome cultural barriers) was the survey item with the third least agreement. Item 26 was the statement that represented the greatest range of agreement in Factor 2, with 17.7% agreement among Earth science teachers and 47.6% agreement among physics teachers.

Comparison of responses to items in Factor 2. Factor 2 represented items with which teachers had high overall agreement (i.e. Item 22 Cultural norms in America advantage certain populations over others with 97.3% agreement for the total sample of teachers) and overall low agreement (i.e. Item 25 Only schools serving multicultural students need diverse staff and faculty which had an overall agreement of 7.5% among the total sample of teachers). Most of the items (seven of 11 items) had less than 50% agreement among the sample of all teachers and there was general consistency in the ordering of items when comparing the percentage agreements of the four content area groups.

Item 26 (It is the student's responsibility to make accommodations to overcome cultural barriers) had the widest range of agreement (17.7% for Earth science to 47.7% for physics teachers) between the teachers of different disciplines for Factor 2. Item 26 was also the only item in Factor 2 that showed a shift in range of agreement of greater than 10% after removing the responses of one content area (i.e., physics). The 29.9% range of agreement for Item 26 contracts to 8.9% and highlights that physics teachers were more likely to agree with Item 26 than teachers of other content areas.

Factor 3 (Challenges of Working in Settings with Students of Multicultural Backgrounds)

The analysis reported in this section is based on teacher responses to the 12 Likert items relating teacher beliefs on the challenges they face when working with students of multicultural backgrounds in the context of the science classroom.

Across all disciplines of science, there was consistent agreement with the belief that all students, regardless of cultural background, should be held to the same academic expectations. There was noticeably less agreement for all groups with the attitude that multicultural students are as likely to succeed in upper level and honors classes. And though there was generally low agreement with the belief that culturally diverse students are less academically prepared for achievement in science, chemistry and physics teachers showed more agreement with the statement than biology and Earth science teachers.

Total sample of teachers. The percentage of agreement for the total sample of teachers for each of the Likert items in Factor 3 is presented in Table 4.9. As previously noted, a complete representation of responses to the Likert items for Factor 3 is presented in the appendices, and only illustrative examples are presented here.

Similar to Factor 2, there was a broad range in agreement among the responses to the items in Factor 3. Percentages for all items ranged from 6.2% agreement to 86.3% agreement, with most items having less than 50% agreement.

Table 4.9

Agreement with Likert Items Pertaining to Factor 3: Challenges and Concerns Related to Working with Students of Multicultural Backgrounds

Abbreviated items	Percentage agreement				
	Total (n=152)	Biology (n=67)	Chemistry (n=44)	Physics (n=22)	Earth sci (n=19)
30. Students of multicultural backgrounds often have greater difficulty with understanding science content.	15.1	9.4	20.5	19.1	17.7
31. Cultural diversity in a class makes it more difficult to teach science content.	14.5	11.1	13.6	23.8	17.7
32. Multicultural students are more likely to require remedial courses.	26.9	23.8	27.3	23.8	41.2
33. Sharing cultural perspectives takes away from the time for science content.	14.4	14.1	18.2	9.5	11.8
34. Culturally diverse students are less academically prepared for achievement in science.	33.8	25.4	38.6	42.9	41.2
35. I am less likely to contact a student's home if there are cultural barriers between me and their parents.	20.7	20.3	25.0	25.0	5.9
36. I would prefer to work with students with cultural backgrounds similar to mine.	8.2	12.5	0.0	14.3	5.9
37. White people place a higher value on education than other cultures.	6.2	4.7	7.0	0.0	16.7
38. Multicultural students are as likely to succeed in upper level and honors classes.	59.0	66.7	47.1	47.6	58.1
39. To become successful in America, people from multicultural backgrounds should adopt mainstream cultural practices.	36.9	34.9	43.2	38.1	27.8
40. Multicultural education is less important than reading, writing, arithmetic, and computer literacy.	31.8	35.4	27.3	33.3	27.8
41. All students, regardless of cultural background, should be held to the same academic expectations.	86.3	84.4	88.6	90.5	82.4

Item 41 (All students, regardless of cultural background, should be held to the same academic expectations) had the highest percentage agreement among all teachers. Item 38 (Multicultural students are as likely to succeed in upper level and honors classes) with 59.0% agreement among all teachers, represented a large drop to second rank. With 6.2% agreement among all science teachers surveyed, Item 37 (White people place a higher value on education than other cultures) had the least agreement. And with 8.2% agreement, the second lowest ranked item was Item 36 (I would prefer to work with students with cultural backgrounds similar to mine). There was low agreement (14.4% agreement) with Item 33 (Sharing cultural perspectives takes away from the time for science content). And although the beliefs were not held by a majority of all teachers, it may be of some concern that approximately a third of the respondents (33.8%) agreed with Item 34 (Culturally diverse students are less academically prepared for achievement in science) and more than a quarter of respondents (26.9%) agreed with Item 32 (Multicultural students are more likely to require remedial courses).

Content specialties of teachers. The data for percentage agreement for these items are presented in Table 4.9, and a complete description of the data can be found in the appendices. As noted in the sub-section on *Total sample of teachers*, there was a wide range in percentage agreements for the items in Factor 3. The greatest range of agreement was for physics teachers with a range of agreement of 90.5% to 0% agreement. Chemistry teachers had a range of 84.4% to 0% agreement. Biology teachers had a range of 4.7% to 84.4% agreement. Earth science teachers, with a range of 5.9% to 82.4% agreement had the tightest range. For all four disciplines Item 41 had the greatest percentage agreement, though the least agreement varied between Item 36 and Item 37.

Item 38 had the largest range of agreement between the different specialties, with 47.1% agreement among Earth science teachers and 66.7% agreement among biology teachers. Item 38 (Multicultural students are as likely to succeed in upper level and honors classes) was consistently the second most agreed upon item. For Item 38, it is interesting to note that there was a stepwise progression from the 66.7% agreement among biology teachers, to a 58.1% agreement among chemistry teachers, and 47.6% and 47.1% agreements respectively for physics and Earth science teachers. Though there were lower percentage agreements Item 35 (I am less likely to contact a student's home if there are cultural barriers between me and their parents) had a similar range of agreement with 5.9% agreement among Earth science teachers and 25% agreement among chemistry and physics teachers.

The tightest range of responses among the teachers of different disciplines was represented by Item 41 (All students, regardless of cultural background, should be held to the same academic expectations), which was the highest agreed upon item for all teachers and had a range of 82.4% to 90.5% agreement; and Item 40 (Multicultural education is less important than reading, writing, arithmetic, and computer literacy), which had a range of 27.3% to 35.4% agreement. There were comparatively larger ranges of agreements for Item 34 (Culturally diverse students are less academically prepared for achievement in science) with a range of 25.4% agreement among biology teachers to 42.9% agreement among physics teachers, and Item 32 (Multicultural students are more likely to require remedial courses) with a range of 23.8% agreement among biology and physics teachers to 41.2% agreement among Earth science teachers.

Responses to the Likert items present a pattern of differences between the responses of biology teachers and teachers of other disciplines on their beliefs regarding the preparation and likelihood for success of multicultural students. This pattern is evident from responses of lower agreement to Items 30 and 34, coupled with the higher agreement with Item 38. For Item 30 “Students of multicultural backgrounds often have greater difficulty with understanding science content,” there was nearly a 10% gap in agreement between biology teachers (9.4% agreement) and teachers of other disciplines (20.5% agreement among chemistry teachers, 19.1% agreement among physics teachers, and 17.7% gap among Earth science teachers) indicating that there was consistently greater agreement among the teachers of the other three disciplines that multicultural students have difficulty understanding content.

For Item 34 (Culturally diverse students are less academically prepared for achievement in science) there was again a fairly consistent gap, approximately 15%, when comparing the beliefs of biology teachers (25.4% agreement) with the beliefs of teachers of other disciplines (38.6% agreement among chemistry teachers, 42.9% agreement among physics teachers, and 41.2% gap among Earth science teachers) indicating that teachers of the other three disciplines were more likely to view multicultural students as less likely to be prepared for achieving success in science. These results were consistent with the already reported higher agreement among biology teachers for Item 36 (Multicultural students are as likely to succeed in upper level and honors classes) in comparison to the teachers of the other subjects, indicating that although the belief was not shared by a majority of biology teachers, there was a higher agreement among biology teachers than those of other disciplines that multicultural students will be able to be successful as they progress through to higher level sciences than those of the other subject areas.

Comparisons of responses to items in Factor 3. The responses to the items in Factor 3 indicate a strong sense that all teachers agree that all students should be held to the same academic standards, regardless of cultural backgrounds. Still, there was sense of acknowledgement that students of multicultural backgrounds may come into classes less prepared than their White counterparts, may need remediation to achieve success, and may be less likely to succeed in upper level and honors classes.

Biology teachers, who are often the first high school science teachers students have experience with, demonstrated the least agreement with items reflecting the difficulty that multicultural students face with science content and had the highest agreement that multicultural students will be able to succeed in upper level science courses. Although approximately a third of all respondents (33.8%) agreed with Item 34 (Culturally diverse students are less academically prepared for achievement in science), agreement with the statement among biology teachers (25.4% agreement) was far lower than the agreement of other subject area teachers with the statement. Similarly, there was a relatively low agreement overall (15.1% agreement) with Item 30 (Students of multicultural backgrounds often have greater difficulty with understanding science content), but there was less agreement with the item among biology teachers (9.4% agreement) than there was for the other three disciplines. Biology teachers also showed a greater agreement (66.7%) agreement with Item 38 (Multicultural students are as likely to succeed in upper level and honors classes). The percentage agreement of biology teachers was close to the overall agreement among all teachers (59% agreement for all teachers) but still higher than that of teachers of the other three disciplines (58.1% agreement among chemistry teachers, 47.6% agreement among physics teachers, and 47.1% agreement among Earth science teachers), with the differences being especially pronounced in comparison to physics and Earth science teachers. Earth science teachers were in greater agreement (41.2% agreement) with Item 32 (Multicultural students are more likely to require remedial courses) than teachers of any of the other discipline.

Factor 4 (Instructional Practices)

The analysis reported in this section is based on teacher responses to the eight Likert items about teacher practices in the context of the science classroom. Similar to the previous section, the major findings for the section will be presented first, followed by more in depth analysis of the results of the study. Responses of agreement with Likert items for Factor 4 are presented in Table 4.10. A complete representation of responses to the Likert items for Factor 4 is presented in the appendices.

Table 4.10

Agreement with Likert Items Pertaining to Factor 4: Instructional Practices

Abbreviated items	Percentage agreement				
	Total (n=152)	Biology (n=67)	Chemistry (n=44)	Physics (n=22)	Earth sci (n=19)
42. Students from different cultural backgrounds learn better from different methods of instruction.	57.1	57.8	52.3	66.7	55.6
43. I make changes to my instruction to address cultural differences.	68.5	76.0	65.9	57.1	64.7
44. Science instruction should have a focus on understanding inequities and cultural differences.	48.3	52.4	47.7	33.3	52.9
45. I include content related to the backgrounds of multicultural students.	65.1	71.9	56.8	57.1	70.6
46. Science instruction should have a focus on taking social action to address inequities and cultural differences.	47.3	42.2	45.5	47.6	70.6
47. It is the teacher's responsibility to address cultural barriers to understanding content.	91.8	93.8	90.9	90.5	88.2
48. A student's cultural background correlates to performance in science.	50.3	46.9	45.5	71.4	50.0
49. Multicultural education is most beneficial for students of multicultural backgrounds.	18.9	18.5	20.5	0.0	22.2

There was high agreement across all disciplines with the belief that it is the teacher's responsibility to address cultural barriers to understanding content, but there was noticeably less agreement with the statements reflecting attitudes on including content related to the backgrounds of multicultural students or making changes to instruction to address cultural differences. Also, of note was the higher agreement of physics teachers with the statement that a student's cultural background correlates to performance in science in comparison to teachers of other disciplines.

Total sample of teachers. Percentage agreement for all items ranged from 18.9% agreement to 91.8% agreement, with most items falling in a range of 40% to 70% agreement. Item 47 (It is the teacher's responsibility to address cultural barriers to understanding content) was the statement with the highest percentage agreement among all teachers. With 65.1% agreement among all teachers, there was a fairly large drop to second ranked Item 45 (I include content related to the backgrounds of multicultural students). Item 49 (Multicultural education is most beneficial for students of multicultural backgrounds) had the least agreement with 18.9% agreement among all teachers. With just under half of all teachers agreeing, the next two items of lowest agreement were Item 46 (Science instruction should have a focus on taking social action to address inequities and cultural differences), which had 47.3% agreement and Item 44 (Science instruction should have a focus on understanding inequities and cultural differences), which had 48.3% agreement.

Content specialties of teachers. The ranges of positive responses for teachers of the different content specialties generally reflected the patterns for the overall sample of teachers. Item 47 (It is the teacher's responsibility to address cultural barriers to understanding content) had the highest agreement among teachers of all four content areas (93.8% agreement among biology teachers, 90.9% agreement among chemistry teachers, 90.5% agreement among physics teachers, and 88.2% agreement among Earth science teachers). Item 49 (Multicultural education is most beneficial for students of multicultural backgrounds) had the lowest agreement among teachers of all four content areas (18.5% agreement among biology teachers, 20.5% agreement among chemistry teachers, 0% agreement among physics teachers, and 22.2% agreement among Earth science teachers).

The greatest range of agreement for one group across all items was for physics teachers with a range of agreement that ranged from 0% agreement with Item 49 to 90.5% agreement with Item 47. Biology teachers had an overall range of agreement of 75.3% (18.9% agreement with Item 49 and 93.8% agreement with Item 47). Chemistry teachers had an overall range of agreement of 70.4% (20.5% agreement with Item 49 and 90.9% agreement with Item 47). Earth science teachers had the smallest range of agreement of 66% (22.2% agreement with Item 49 and 88.2% agreement with Item 47).

Item 47, which had already been identified as the item of highest agreement for the four content areas, also represented the smallest variation of agreement among the four content areas, having a range of agreement of 5.6% (93.8% agreement among biology teachers to 88.2% agreement among Earth science teachers). The greatest range of agreement when comparing across the four disciplines was Item 46 (Science instruction should have a focus on taking social action to address inequities and cultural differences), which a range of agreement of 28.4% (70.6% agreement among Earth science teachers and 42.2% agreement among biology teachers).

Five items in Factor 4 had ranges of agreement that decreased by more than 10.0% when either the content area of highest agreement or lowest agreement was removed. For Item 46, which has already been mentioned, comparing the other three content areas in absence of Earth science teachers decreases the range of agreement from 28.4% to 5.4%. Item 48 (A student's cultural background correlates to performance in science) had a range of agreement of 25.9% (71.4% agreement among physics teachers compared to 45.5% agreement among chemistry teachers) tightens up to a range of 4.5% without physics teachers. For Item 49, which was already identified as the item of lowest agreement for all four content areas, the overall range of agreement (22.2% agreement among Earth science teachers compared to 0% agreement among physics teachers) shrinks to a range of 3.7% when removing physics teachers. Item 43 (I make changes to my instruction to address cultural differences), which had a range of 18.9% agreement (75.0% agreement among biology teachers compared to 57.1% agreement among physics teachers), the gap in agreement among the other three content areas reduces to 8.8% when not including biology teachers. Item 44 (Science instruction should have a focus on understanding inequities and cultural differences) had a range of agreement of 19.6% (52.9% agreement among Earth science teachers compared to 33.3% agreement among physics teachers), which shrinks to a range of 5.2% agreement with the removal of physics teachers.

Comparisons of responses to items in Factor 4. Factor 4 represented the largest clustering of items around the beliefs and attitudes teachers had regarding their instructional practices when working with multicultural students in the science classroom. Of the eight items in Factor 4, Item 47 (It is the teacher's responsibility to address cultural barriers to understanding content) was the only item with which nearly all teachers (91.8% agreement among the total sample of teachers) agreed. Item 49 (Multicultural education is most beneficial for students of multicultural backgrounds), having a percentage agreement among the total sample of teachers of 18.5%, was clearly the item with which teachers least agreed with. The remaining six items fell in a range of 42.2% agreement to 68.5% agreement among all teachers. In comparing the percent agreement of the four areas of content specialty, the samples of biology and chemistry teachers were consistent in the order in which their agreement with all eight questions were ranked. This represented the only instance of two samples of content specialty groups having the same ranking of agreement across all five Factors.

Factor 4 also had the largest number of items in which the agreement among teachers of one subject varied greatly from the remaining three subject areas. There were five items in Factor 4 for which removing the group that had the highest agreement or lowest agreement among teachers of the same discipline would decrease the range of agreement among the other three groups by at least 10%. Three of the extreme values represented the beliefs of physics teachers. For Item 48 (A student's cultural background correlates to performance in science) removing physics teachers, who with a 71.4% agreement among teachers represented the highest agreement, decreases the range of agreement from 25.9% to 4.5% (45.5% agreement among biology teachers and 50.0% agreement among Earth science teachers). For Item 44 (Science instruction should have a focus on understanding inequities and cultural differences), removing the low value for physics teachers (0% agreement) decreases the range from 22.8% to 3.7%. For Item 43 (I make changes to my instruction to address cultural differences), removing biology teachers, who with a 76.0% agreement among teachers represented the highest agreement, decreases the range of agreement from 18.9% to 8.8%. And for Item 46 (Science instruction should have a focus on taking social action to address inequities and cultural differences), removing the high of Earth science teachers (70.6% agreement), decreases the range of agreement from 28.4% to 5.4%.

Factor 5 (Teacher Preparation)

The analysis reported in this section is based on teacher responses to the five Likert items related to teacher beliefs on their preparation for working with students of multicultural backgrounds Similar to the previous section, the major findings for the section are presented first, followed by more in depth analysis of the results of the study. Responses of agreement with Likert items for Factor 5 are presented in Table 4.11. A complete representation of responses to the Likert items for Factor 5 is presented in the appendices.

Table 4.11

Agreement with Likert Items Pertaining to Teacher Preparation

Abbreviated items	Percentage agreement				
	Total (n=152)	Biology (n=67)	Chemistry (n=44)	Physics (n=22)	Earth Sci (n=19)
50. I feel adequately prepared to teach students of diverse cultural backgrounds.	82.9	83.5	81.8	84.0	81.8
51. Upon reflection of my responses to the survey, I feel adequately prepared to teach students of diverse cultural backgrounds.	80.8	85.9	68.2	90.5	82.4
52. I meet with other teachers or staff to address concerns before contacting homes if there are cultural barriers between me and their parents.	69.9	65.6	65.9	95.2	64.7
53. Only schools serving multicultural students need a racially, ethnically, and culturally diverse faculty.	7.4	6.1	13.6	0.0	5.6
54. The cultural backgrounds of the classes I teach represent the cultural makeup of the school.	77.1	74.1	77.3	75.0	88.2

There was relatively high agreement among teachers of all disciplines when initially asked about feeling that they were adequately prepared to work with students of multicultural backgrounds. However, when asked again at the end of the survey, chemistry teachers showed less agreement with the statement, physics teachers showed a slight increase in agreement, and biology and Earth science teachers remained relatively the same. Also, of note was the comparatively higher agreement of Earth science teachers with the statement that their classes were representative of the cultural makeup of the schools they worked in when compared to teachers of other content areas.

***Total sample of teachers*.** Percentage agreement for all items ranged from 7.4% agreement to 82.9% agreement, with four out of the five items falling in the range of 70% to 83% agreement. Item 50 (I feel adequately prepared to teach students of diverse cultural backgrounds) and Item 51 (Upon reflection of my responses to the survey, I feel adequately prepared to teach students of diverse cultural backgrounds) represented the same question being asked at the beginning of the survey and again at the end of the survey. Item 50 indicated that most science teachers (82.9% agreement) felt adequately prepared to work with students of multicultural backgrounds at the beginning of the survey. Comparison of the responses to Item 51 (80.8% agreement) to the response to Item 50 demonstrated a minimal change and seemed to indicate that the process of completing the survey did not result in any immediate shifts in the beliefs of the total sample of science teachers in regards to their preparation to work with students of multicultural backgrounds.

A majority of science teachers (77.1%) agreed with Item 54 “The cultural backgrounds of the classes I teach represent the cultural makeup of the school.” There was less agreement (69.9% agreement) with Item 52 (I meet with other teachers or staff to address contacting homes if there are cultural barriers between me and their parents). The lowest agreement (7.4%) was with Item 53 (Only schools serving multicultural students need a racially, ethnically, and culturally diverse faculty).

Content specialties of teachers. The ranges of positive responses for teachers of the different content specialties generally reflected the patterns for the overall sample of teachers. Item 50 (I feel adequately prepared to teach students of diverse cultural backgrounds), which was the first Likert question presented in the survey, had the smallest variation of percentage agreement with a range of 2.2% between the four disciplinary groups (83.5% agreement among biology teachers, 81.8% agreement among chemistry teachers, 81.8% agreement among physics teachers, and 81.8% agreement among Earth science teachers). Item 51 (Upon reflection of my responses to the survey, I feel adequately prepared to teach students of diverse cultural backgrounds), which presented the same question after teachers had an opportunity to complete the survey, had a much larger range of 22.3% between the groups. This shift in range could be attributed to the decrease in the percentage agreement among chemistry teachers, from 81.8% for Item 50 at the beginning of the survey to 68.2% for Item 51 at the end of the survey, and the increase of percentage agreement for physics teachers from 84.0% for Item 50 at the beginning of the survey to 90.5% for Item 51 at the end of the survey. Percentage agreement stayed relatively consistent between the two items for biology teachers (83.5% agreement for Item 50 to 85.9% agreement for Item 51) and Earth science teachers (81.8% agreement for Item 50 to 82.4% agreement for Item 51). These results indicated that process of completing the survey may have given some teachers, particularly those who taught chemistry, an opportunity to reflect on, and reassess, their feelings of preparedness for working with students of multicultural backgrounds.

Item 52 (I meet with other teachers or staff to address contacting homes if there are cultural barriers between me and their parents) had the largest range of agreement (30.5%) between the different specialties, with 64.7% agreement among Earth science teachers and 95.2% agreement among physics teachers. The percentage agreement of physics teachers for Item 52 was in such contrast with those for the teachers of the other three disciplines (65.6% agreement among biology teachers, 65.9% agreement among chemistry teachers, 95.2% agreement among physics teachers, and 64.7% agreement among Earth science teachers) that the removal of physics teachers resulted in a decrease of the range for percentage from 30.5% to 1.2%.

Item 53 (Only schools serving multicultural students need a racially, ethnically, and culturally diverse faculty) had a range of agreement of 13.6% (6.1% agreement among biology teachers, 13.6% agreement among chemistry teachers, 0.0% agreement among physics teachers, and 5.6% agreement among Earth science teachers). Though there was low percentage agreement for Item 53 among all disciplines, it is of note that biology and Earth science teachers were similar in their level of agreement, with chemistry and physics teachers, respectively, representing the highest and lowest percent agreements.

Earth science teachers had a greater percentage agreement for Item 54 (The cultural backgrounds of the classes I teach represent the cultural makeup of the school) than teachers of the other three disciplines (74.1% agreement among biology teachers, 77.3% agreement among chemistry teachers, 77.3% agreement among physics teachers, and 88.2% agreement among Earth science teachers). The removal of Earth science teachers resulted in a decrease in the range for percentage agreements to decrease from 14.1% to 3.2%.

Comparisons of responses to items in Factor 5. As stated in the *Total sample of teachers* section, a majority of respondents (69.9%) agreed with Item 52 (I meet with other teachers or staff to address concerns before contacting homes if there are cultural barriers between me and their parents). The results of this item should be put into context with the 20.7% agreement with Item 35 (from Factor 3; I am less likely to contact a student's home if there are cultural barriers between me and their parents) and 91.8% agreement with Item 47 (from Factor 4; It is the teacher's responsibility to address cultural barriers to understanding content). In concert, these three items indicate that although there was a high level of agreement on teachers being responsible for addressing cultural barriers, there was a large drop in the percentage of teachers who will work with others before making contact to parents' homes, with approximately a fifth of teachers indicating that they were less likely to make contact home.

4.5 Main Findings from Quantitative Analysis

Figure 4.6 summarizes the main findings from the three lines of analysis (i.e. non-parametric comparison testing, correlation network analysis, and comparisons of Likert responses) conducted during the quantitative portion of the study which link to Research Question 1, which addressed the presence of differences in attitudes and beliefs of in-service science teachers of different content areas in regards to multiculturalism in the science classroom.

Figure 4.6

Summary of Main Findings of Quantitative Analysis on Differences in Attitudes and Beliefs of In-service Science Teachers

- Comparison testing indicates statistically significant differences for only 5 out of 54 Items on the Survey of Multiculturalism in the Science Classroom
    - Physics teachers are the only content area group represented in all 5 of the items that indicate difference.

- Correlation network analysis indicates that physics and chemistry teachers, in comparison to biology and Earth science teachers, have richer interconnections among items reflecting beliefs and attitudes about to multiculturalism.

- Responses to Likert items indicate that all teachers share a belief that cultural diversity as a positive but show less agreement with attitudes reflecting the need to address multiculturalism in science instruction.
    - Biology and Earth science teachers show greater agreement with need to address multiculturalism, compared to chemistry and physics teachers.

Chapter 5: Results of Qualitative Analysis

This section presents the results for qualitative analysis of face to face interviews conducted with 12 volunteers representing the four content area specialties of science (i.e., biology, chemistry, physics, and Earth science). The focus of the interviews was to compare responses about the teachers' beliefs and attitudes on multiculturalism and establish possible rationales for any differences for Research Question 1 (How can we characterize differences in the beliefs and attitudes of in-service secondary science teachers of different content specialties (i.e., biology, chemistry, physics, and Earth science) in regards to working with multicultural students in secondary science classroom settings?) and Research Question 2 (What underlying factors or patterns impact the beliefs and practices of secondary science teachers in regards to working with multicultural students?)

Five of the participants identified themselves primarily as biology teachers, two as chemistry teachers, three as physics teachers, and two as Earth science teachers based on their state teaching certifications and the courses that they were currently teaching. Six of the teachers interviewed all worked in the same suburban high school setting and the other six all worked in the same urban high school setting. Pseudonyms were given to those interviewed and information about the participants is presented in Table 3.2. For ease of the reader, the first letter of each participant's pseudonym correlates with the first letter of the content are they represent (i.e., Blanca is a biology teacher, Chris is a chemistry teacher, Pam is a physics teacher).

This section presents several of the themes that emerged from the open-coding analysis of the interviews conducted with the twelve participants. The sections are organized with the themes in mind, and when appropriate accompanied by driving question that helped to guide the analysis within the theme. The interviews were open ended and integrated questions from an interview protocol developed at the beginning of study, probing questions that asked participants to elaborate or verify responses, and questions that asked about themes that emerged during initial analysis of both the quantitative data and prior interviews. The interview protocol is presented in Appendix D.

Before proceeding, it should be noted that during the course of the following sections the variations in cultural or racial descriptions (i.e., Spanish, Hispanic, Black, African-American, Caribbean, and Caribbean-American, etc.) reflect the language used by the participants. Also of note, though there was some consideration taken for possible interactions that may exist based on whether the teachers were teaching in an urban or suburban setting, the study did not directly address such differences and the analysis identified only a few instances where teachers within a subject area were split based on school setting.

5.1 Research Question 1

The purpose of this question (How can we characterize differences in the beliefs and attitudes of in-service secondary science teachers of different content specialties (i.e., biology, chemistry, physics, and Earth science) towards working with multicultural students in secondary science classroom settings?) was to compare the beliefs and attitudes of the participants on multiculturalism and working with students from multicultural backgrounds and examine patterns that emerged based on the subject specialties of the teachers. The first two sections detail teacher responses about their beliefs with a focus on how they define multiculturalism and their personal beliefs on the importance of multiculturalism. This is followed by a review of their attitudes on the importance they place on identifying the cultural background of a student and how they identify if a student is multicultural. This section also draws on the attitudes of teachers regarding the student' experiences outside of the classroom and how successful they feel a student of multicultural background can be in science. Overall, the interviews indicated very similar patterns of beliefs across teachers of all four content areas, though there were identifiable differences in the attitudes expressed by the teachers of different subject areas.

Patterns of Differences in the Definition of Multiculturalism

This section focuses on how participants defined multiculturalism. For purposes of this study, these definitions were classified as beliefs because of their inherently internal cognitive nature. When asked how they define multiculturalism all 12 participants indicated race, 10 participants indicated nationality or country of origin, 10 indicated religion, nine indicated cultural practices (food, music, dress, or customs), eight indicated language, seven indicated social class, five indicated gender, and four indicated sexual orientation. When examining the definitions across the content areas, all biology and Earth science teachers indicated nationality or country of origin as well as cultural practices as indicators of cultural background. Of the12 teachers interviewed, chemistry teachers were the only ones to not mention nationality or cultural practices of the students as indicators of multiculturalism. Chemistry teachers were the only content area not to include language as a descriptor.

Patterns of Differences in Personal Beliefs on Multiculturalism

When asked about their personal beliefs about multiculturalism in the context of their lives, all 12 teachers shared common beliefs that the exposure to different cultural backgrounds is positive and necessary to widen their perspectives. Eight of the teachers indicated that growing up in multicultural neighborhoods exposed them to a diversity of ideas or experiences. Beatrice, a biology teacher, indicated that "growing up in an area with a lot of diversity gave [her] a chance to know people from many backgrounds, learn about many different perspectives, and even question some of the ideas that her parents had presented to her." Cathy, a chemistry teacher stated:

> Many of my closest friends are from different backgrounds, even my husband is from a completely different background, and it never stops amazing me that even for all our differences we learn to appreciate how much life has to offer us.

Brooke, a biology teacher, added that diverse cultures "makes it interesting to eat different foods, learn different dances, hear different stories, and explore different cultural experiences."

Another common response shared by seven of the 12 participants was the benefits of understanding different cultures in the context of travelling to other countries. Peter, a physics teacher, indicated that one of his "favorite pastimes is to travel to other countries and learn about different cultures and experience things that he would never get to see if he just stayed in one place." Emma stated that "being comfortable with being in other cultures has also let me experience going on a safari ride and seeing some of the land and weather features, like the Great Rift Valley or the monsoons in Asia, that I can discuss and show pictures of to my students." Chris, a chemistry teacher, summed up the similar sentiments expressed by all the teachers interviewed on the need for learning about diverse cultures. He stated, "It's a broad world that we live in and we have to be open to it all because it's by sharing our different experiences and views that we evolve and grow as individuals and as a civilization." None of the teachers expressed any negative attitudes or beliefs when discussing their views on multiculturalism.

Patterns of Differences in Identifying Multicultural Students

This section focuses on the importance teachers attributed to identifying the backgrounds of students and how participants identified students as being multicultural. For purposes of this study, the importance placed on identifying a student as multicultural was considered an attitude because it represented a behavioral act on the part of the teacher. This section also explores how the teachers determined if their students were multicultural to make connections to how their attitudes were expressed by their actions.

What patterns emerge when comparing attitudes of teachers of different content area specialties on the importance of identifying students as being multicultural?

During the interviews there was an underlying pattern of biology and Earth science teachers indicating a greater importance for identifying students as being of multicultural backgrounds than chemistry and physics teachers. This pattern aligned with the teachers' use of physical and/or cultural indicators to make such determinations. For example, when asked about identifying the cultural backgrounds of their students, the biology and Earth science teachers all agreed that it was very important to get an understanding of the cultures to plan accordingly. All five biology teachers and both Earth science teachers shared sentiments stating that the teacher having knowledge of a culture allowed for them to make instructional connections to student knowledge and experiences. Beatrice stated:

> Knowing about a culture is really important because I want to attach new information to some form of information that's already in their brain and if I know about a kid's ancestral culture I can use examples of food or animals or whatever they already know and get them all to say "okay, that's what she's talking about."

Blanca gave an example from her biology classes of how developing her understanding of different cultures has made it possible to make deep connections to content, such as expanding on the nutrition unit by including references to how the different cuisines that the students are accustomed to at home interact with their bodies:

> Cultural connections are so important…when we talk about nutrition I will talk about food that my students eat and not just hamburgers and pasta, but curries, and fanesca, and morocho, and naan, and kapsa… we talk about where the proteins are and the carbs and how they balance their meals… And then the kids go home and talk about it and really connect. Because we can put that unit in terms of culture and food the kids get a really good understanding of how the body processes food, and more importantly they care about it.

Elise shared about her Earth science classes and how having knowledge about where a student, or a student's family, originates from can be used to make connections between cultural experiences and the content:

> when we talk about hurricanes or monsoons, a student whose culture and experiences come from a place that has hurricanes or monsoons is more connected and can share their experiences…it's more tangible.

Emma also elaborated on how important it was to look for ways to make connections between the life experiences of students and the content whenever possible. She included an anecdote about how allowing a student to his culture led to his connecting with Earth science and improving his performance:

> At the start of the year [the student] was not doing well in my class. He didn't do much work and was failing. I had learned that he came from Peru and had experiences with earthquakes. When we got up to the topic, he seemed to show more interest, so I gave him more material and let him share with the class how part of his life revolved around being ready for earthquakes. He was really into it and it changed how he connected to the material and to the other students in the class… And even when we moved onto plate

> tectonics and erosion, he was into it… he totally changed once we hit that topic …connecting to that bit of his culture was important for him to connect to the course.

Beyond just finding personal connections, teachers also expanded on the importance of understanding different cultures and knowing the cultural backgrounds of students in order make curricular decisions that take those perspectives into consideration. Having worked with Middle Eastern and South Asian students of Muslim backgrounds, Badra gave an example of how she addressed cultural norms that could otherwise impact a student's exposure to content:

> Muslim girls who are new to the country are very shy about their own body… they may not have learned about it and were taught to not ask questions, so when we talk about the body, and specifically about reproduction, [the students] shy away from the topic and don't participate in discussion and then do poorly on something that will be important for them to understand

Badra elaborated how her experiences had taught her that she had to find alternate and culturally responsive methods of approaching certain subject matter to connect with students who were uncomfortable that material.

> I used to just teach about reproductive anatomy and reproduction in an objective way… one day I realized that some of my [female Muslim] students would miss class or not do the work and do badly on the material… when I realized the pattern I made some changes… even though it was not in our curriculum I would introduce reproduction in other organisms before discussing reproduction in humans. I started to see a change in how the students were in class and how they did on my tests. It made them more comfortable and made it easier for them to talk about the concepts more generally and to learn about their bodies.

Beyond making connections with student experiences, another idea linked to the importance of knowing the cultural background of a student related to the students' experiences with a different educational system. This was expressed by two biology teachers and one Earth science teacher, and best summed up by Badra, who had come from another culture as an adult and drew on personal experiences about the shifts in schooling that students may have to adjust to:

> In some cultures, school is very different… I know because I taught in India for many years and still have friends who do. Class size is really big, a class of 50 students in one room… there's less opportunity to participate in discussion and not many activities…it's very teacher-centered. We try to do things very differently here… and when they are coming new, it takes some time to get used to a different structure in the classroom

Badra elaborated on the importance of how knowing about how the student was taught so that she could try to accommodate the students and ease them into a different learning culture:

> It can take months to get used to the new class and it can be difficult for them and they might miss a lot in that time… If I know that they have only ever had lecture, I may give them more direct teaching while other students work on projects and give them a little more time to learn how to work with other students before they have to be in a group with other students.

This response of understanding the educational background of a student was a concern demonstrated by three of the biology teachers and both Earth science teachers. Contained within this theme was also an aspect of differentiating, and to some extent stereotyping, the different cultural backgrounds present in the classroom. Betty indicated that knowing the cultural background shaped her expectations for students, and framed it in the context of anticipating the motivations of different students:

> Another reason I try to find out about a student's culture is understand the value of education the family might put on school. I think families come here for different reasons… ones coming from India and Pakistan for the "American Dream." You get an education here and you have more opportunity here, so they really focus on getting an education above all else… where I think for the Hispanic, it's more leaving an area that is not safe and then getting a job to stay here.. so, the kids have attendance issues and it's because they are trying to balance school and having job and then truancy becomes a problem… and then it becomes a puzzle how to plan something to get the most of the time they are in the room.

Similarly, Emma commented on how she felt that in order to plan and differentiate instructions appropriately, it was important to identify the backgrounds of students and understand the emphasis that families placed on learning about science:

> The amount of support a student get has a lot of impact on what I can plan to give them. Some cultures are focused on science and math and others I don't see as pushing science as heavily. A lot of my students who are South Asian are pushed to be doctors or engineers and have parents or family that are in science related jobs. Science seems big in their ancestral homelands and their parents promote getting a science education…
> And then I also see parents of Spanish or Black students who don't understand science and think that it's too hard and not important, so they are happy to see their students pass. Just because their child is showing up and passing, they feel their child is more successful

than them, but they are actually less successful than the standard set by other students. And it can be really hard to push a student to do better if there is no support from home.

Elise also shared similar concerns about the impacts that the background of a student has on their performance in science, indicating that she saw a pattern of differences in the performance of Asian students in comparison to Black and Hispanic students. During her interview she did also present a counter narrative that broke from that narrative:

> It's not to say that only White and Asian students can be successful. I've also taught many Hispanic and Black students who did really well in class and may do better than their peers. I had our most recent valedictorian in my class several years ago and she was a remarkable woman. She came from Columbia and barely spoke any English when she was in middle school. But she worked really hard and became the top of her class. I remember her taking time to go over all her notes and asking questions when she didn't understand. She would translate her notes into Spanish and even translated for her parents during parent teacher meetings. She was eloquent and incredibly smart and by senior year was taking AP [Advanced Placement - college credit bearing] courses in science, math, and English.

In contrast to the biology and Earth science teachers, chemistry and physics did not show as strong a concern for identifying the multicultural backgrounds of their students. Chris, whose perspective was shared by both chemistry teachers and two physics teachers, shared his attitude on not finding it necessary to identify the cultural backgrounds of his students:

> The students in my chemistry classes are expected to focus on the chemistry regardless of their background, race, or ethnicity. Chemistry is pretty much the same wherever you go and I focus on the content more than anything else... much of what I teach is abstract and

> based on math … kids from some backgrounds may be better or worse at math than others or may put more emphasis on learning than others, but that's not really all that different whether a student comes from a White, Black or Asian… maybe there is a need to differentiate, but that would be based on how well the student is doing not on the what race or ethnicity they come from.

Pam, who taught in the urban setting, acknowledged cultural differences existed, but did not feel the need to identify the backgrounds of her students, indicating that she did not feel the need to differentiate instruction based on the cultural backgrounds of her students:

> There's definitely cultural diversity in my physics classes. There are Black students as well as Hispanic students, Caribbean students, Indian students, Chinese students and Philippino students. If any lack of diversity, it's that there are only two White students in my classes. There are definitely differences in the way some of the students who immigrated more recently dress or speak, but everyone in my class is doing really well regardless of their background. I don't really have to change my instruction for anyone … not based on race anyway.

Peter shared that identifying a student's background was not something he had previously considered:

> Before the survey, I'd never really given any thought to the diversity in my class and never really tried to identify the backgrounds of my students. I just taught physics and figured that they got it or they didn't.

What patterns emerge when comparing how teachers of different content area specialties identify students as being multicultural?

This section focuses on how participants identified students as being multicultural, thus expressing attitudes on the importance of identifying students' cultural backgrounds. There were several components that were consistently part of the definitions that teachers indicated for multiculturalism that did not reappear when making classifications of students. Although teachers in all subject areas used external indicators to identify students as multicultural, those who placed more emphasis on knowing about a student's cultural background also reported using indicators that may not be as noticeable on the surface.

When asked to define multiculturalism, teacher responses included race, nationality, country of origin, religion, food, music, dress, customs, language, social class, gender, sexual orientation. While all 12 teachers indicated that race was the main factor used for identifying a student as being multicultural, eight teachers also indicated the clothing they wear and/or music that students listened to, eight indicated language, and five specifically addressed religion. Though they were previously identified as criteria for multiculturalism, social class, gender, and sexual orientation were not mentioned during the interviews by any of the teachers when they were asked how they identify their own students as multicultural; however, two additional items were included. Eight of the participants indicated the use of student name, and five teachers also indicated they looked at items the students responded to on background surveys distributed at the beginning of the school year.

Cultural identifiers, specifically clothing and music, were indicators of students being from multicultural backgrounds for all biology and Earth science teachers. Only one of the physics teachers identified clothing, and no chemistry teacher identified clothing or music. Elise noted "Jamaican and Caribbean students tend to wear clothes or bandanas that have country flags on them." Beatrice noted, "I can tell if a student is African-American or Caribbean-American based on if they listen to hip hop or reggae music." Pam, who was from the urban setting, noted, "Students who are really new to the country still wear more traditional clothes from places like India or China." Betty noted "a lot of times I hear the Spanish kids who are fairly new hum and sing songs in Spanish, but not as much for the students who are Spanish but grew up here." The four teachers who did not refer to clothes or music as an indicator of cultural background were all physics or chemistry teachers.

All biology and Earth science teachers indicated students' names as an indicator for a student being of multicultural origin. Beatrice stated that "majority of the time, [she] can tell where a student comes from and what level of preparation to expect based on the last name of a student." Badra stated that having had experience with many students from many backgrounds, "students' names give me an idea of where in a country a student comes from and even what social class and background which lets [her] think of examples to use before I meet [the students]." Betty teacher stated that "even before I meet a student, if the student's last name is Spanish, I wonder if the student will be ELL [English Language Learner]." Emma indicated that she "looked at the rosters [of her classes] before the school year begins to determine where [her] students might come from."

Language was reported by eight of the teachers as an indicator for students being of multicultural backgrounds. During the interviews, student language, and more notably the designation of students as ELL, was a major influencer on who they viewed to be multicultural and the attitudes towards working with multicultural students. All five biology teachers and both Earth science teachers indicated language as an aspect of multiculturalism. Phil was the only physics teacher to address language, and he did so in the context of recalling one of his students having to be separated during state testing because he was to receive a copy of the physics exam in Chinese. It should be noted that all five biology teachers and the Earth science teacher in the urban setting consistently brought up issues specific to ELL students when discussing multicultural students. When asked if there were differences between ELL and non-ELL students Betty commented about how, though small in number, the ELL population best represented the needs of multicultural students:

> ELL and immigrant students are really the ones who are the best representation of diversity…they still speak in other languages with their friends and are more likely to wear traditional clothes from where they came from. Don't get me wrong, the Asian, middle-Eastern, Black, and Spanish students who were born here or came here when they were really young also have cultural ties, but they are, for lack of a better term, more Americanized. Their skin may be different, but their culture is pretty much the same as everyone else. The students who are new to the country are the ones that have really big cultural differences.

When asked about ELL students, Beatrice had a similar sentiment on the focus placed ELL students as the representatives for multiculturalism even though they represented a relatively small percentage of multicultural students in the school:

> This school is a mix of a lot of cultures. We have African-American students who would be considered to have a hip-hop culture, we have Caribbean-American Black students who identify as Haitian or Jamaican, we have West Indian students, we have different Hispanic groups from all over Central America and Mexico, we have Asian students who are Bangladeshi, or Sikh, or Punjabi, or Chinese. But whatever group they are, they mix with each other in class, or lunch, or on teams after school. The ELL students are usually grouped together and don't really get to mix with everyone the same way, not really even

with the students of the same background who aren't ELL. So, when we discuss culture, we really tend to stress the connections we can make with the cultures of the ELL students.

Though questions about ELL students were eventually discussed at some point during all 12 interviews, issues specific to ELL students were not addressed by the physics and chemistry teachers in either urban or suburban settings, unless specifically asked. Pam stated

> I know there are ELL students in my classes, but they are either the students who are highly proficient or on the border of testing out of ELL so you wouldn't know it when working with them so we don't really make any modifications for them.

Only five teachers mentioned religion in the discussions of their students. Both Badra and Betty focused on religious practices of Muslim students, such as the wearing of the hijab or not taking active roles in dissection. Both also had a specific focus on the girls and aligned to Badra's comment, "the Muslim girls from traditional families particularly stand out, not just because of their dress, but also because they have a more difficult time discussing their bodies." Blanca, Cathy, and Pam all mentioned religion in the context of describing the same student, a female of Muslim origin.

In addition to indicators based on direct observations, three of the five biology respondents and both Earth science respondents indicated that they gave out surveys during the first weeks of school asking students to describe themselves, including the places they or their family have lived or visited, the languages their parents speak, and their experiences related to the subject. When asked about the surveys, Elise stated that "they give me an idea of who the students are and if there are experiences or interests that can connect to the material", continuing, "as we started to focus on the needs of students who were struggling we also added questions about the family and their backgrounds." Blanca, who identified herself as Hispanic, stated "knowing where the family comes from really helps identify differences even between different Latino or Latina students and even what experiences they may have had before coming to the country." Badra, who identified as Indian (Asian) shared a similar sentiment:

> There are lots of cultural and language differences based on what part of India a student comes from but the students are grouped together… also West Indian students are usually thought of as Indian because of how they look but they have a very different culture.

In comparison to the biology and Earth science teachers, none of the physics or chemistry teachers reported the use of student surveys to learn about their students.

Patterns of Differences in Cultural Backgrounds and Shared Experiences

What patterns emerge in the attitudes of teachers of different content areas regarding cultural backgrounds and shared experiences?

A common theme presented among biology and Earth science teachers in regard to attitudes was acknowledging how the cultural background of the student may limit connections with the experiences or examples called upon in the science classroom and the need to address this issue. This theme was presented in only one of the interviews conducted with the chemistry and physics teachers. Reflecting on student experiences with ecology in the context of biology classes, Betty discussed how the backgrounds of multicultural students can limit their direct experiences with the examples of nature that are most common in the curriculum:

> What we teach really reflects our Western values and lifestyle. When we talk about environment and food chains, we spend a lot of time talking about temperate forests in New York, so lots of the White kids who have gone camping, or hiking, or done other outdoor things have more experience with what. They have seen the woods and animals.

> We talk about the Pine Barrens because that's the kind of thing that the [State] exams have on them. And really, I find that a lot of the students who are Black or Spanish or even Asian don't have the same connection to nature. We use books and videos, but that's not the same as connecting with nature.

Emma described how she had to work field trips into the curriculum to try and increase exposure of multicultural students to experiences that her White students may take for granted:

> I was surprised by how many of my Black students tell me that they had never been to the beach or to the woods… and it seems like a cultural difference. We live near both so our Earth science classes go on a trip every year so they can go for a walk and we can point out features like stream erosion, or clay deposits, or how the tides impact erosion of the shoreline… it's the stuff we talk about in class. But we are cramming all these experiences into one day and it allows for experience, but it's not enough to make deep connections… in comparison to many of the White students who grew up in the same town all seem to have more experience with hiking and going to the beach.

Blanca made a similar connection about the limited experiential connections to curriculum available to multicultural students, citing that the most common examples of food used to nutrition do not connect with all her students:

> In our curriculum when we spend a lot of time talking about a healthy breakfast or lunch. we use examples of calculating the nutrients of cereals or an egg sandwich …There's a whole section in the book we use that looks at a balanced meal and it uses an example of pasta and hamburgers. I didn't think too much about it at first but realized that most of the kids I have don't eat those things and [I] had to start focusing on things they do eat…

> But then the tests they take have examples that are not culturally relevant to them, so I have to try and teach with both.

Likewise, Badra indicated how she had to pull material on genetics from other courses in order to provide examples that were more relevant to her students than the ones in the curriculum:

> When we teach genetics, everything is about blue eyes and brown eyes or hair color, but for most of my students that's not important because everyone they know has brown eyes and dark hair. One year I decided to take material from my [college] biology class and discuss sickle-cell anemia. It made an impact with my Black students because it was something that some of them or their family had so they paid attention and then we talked about survival advantage against malaria and they connected with the idea. There needs to be more examples in the curriculum that connect to issues that these students deal with.

The only reference to cultural connections to the curriculum made by a physics teacher was Phil who stated, "I'm thinking about the lesson on forces I just taught, and I was using the example of ice skating for lack of friction. Now I'm wondering if that was a good example for my students who are not White."

Patterns of Differences in Multicultural Students' Backgrounds in Science

What patterns emerge in the attitudes of teachers of different content areas regarding performance of students of multicultural backgrounds in science classes?

There was a notable difference in the responses of teachers when asked about the performance of students of multicultural backgrounds in science classes. Biology and Earth science teachers had more negative attitudes about the performance of students who were not

White, Asian, and Americanized. In comparison, chemistry and physics teachers indicated that students of all backgrounds were just as likely to succeed in the sciences.

Most of the biology and Earth science teachers distinguished specific multicultural groups as demonstrating poor performance. For example, Badra indicated differences existed among the students of different backgrounds in her school, specifically citing that “the students that come from very traditional Muslim families tend to not do as well in science, especially the girls.” Brooke indicated that “the Hispanic students who are new to the country struggle the most in [her] class”, and Elise indicated that with the exception of the Asian students in the class, the students of multicultural backgrounds tend to do worse that the Americanized students.”

All seven biology and Earth science teachers made references to the difficulties that students of multicultural backgrounds have on assessments and how that performance impacts their grades. Emma made the connection between experience and performance stating, “When the student doesn’t draw on the same experiences, it’s hard for them to understand and explain things… and as a result they don’t do as well when they are tested on it.” The theme of poor performance on assessments was common among the seven teachers as voiced by Beatrice’s comment, “The way we have to use [State] exams to determine how well students know information is really not fair to the students who did not grow up in traditional White households... we are basically setting most of these students up to fail.”

In comparison, the physics and chemistry teachers had neutral or positive attitudes about the performance of multicultural students in their classes with a common consensus that most students in their classes performed well in the sciences, regardless of race. Chris commented, for example, that the “performance of [his] non-White students was on par with the White students.” Phil indicated that he could not recollect any multicultural students doing poorly in his physics classes and that “some of my best and hardest working students have been African-American and Asian.” Peter, who taught in the suburban setting, indicated that he didn’t see any noticeable differences when comparing the performance of White and multicultural students in his class, though he reiterated that his class demographics were probably not a fair representation of the school. Peter elaborated that because his classroom was located in a fairly busy hallway he regularly saw more Black students in the halls than would be indicated by the ratio of Black to White students in his classes Similar to Peter, Cathy and Pam indicated that although all cultural backgrounds were represented and all the students did well in their classes, the demographics were not evenly distributed, with students of Asian or Caribbean-Asian backgrounds making up a majority of the classes they taught. It should be noted that the demographic data, which will be addressed in a later section, indicated a low percentage (5%) of White students among the population of the urban setting.

5.2 Research Question 2

Examination of the responses to the Likert statements on the SMSC and the analysis of statements made during the interviews indicated there were some notable differences in the response patterns of teachers of different content area specialties regarding beliefs and attitudes on working with students of multicultural backgrounds. The purpose of this question (What underlying factors attribute to the patterns of differences when comparing the beliefs and attitudes of secondary science teachers of different content specializations in regards to multiculturalism in the science classroom?) was to review the participants’ responses during the interviews in order identify themes that may explain the differences identified in earlier sections of this study. This section examines two major themes that came up during the interviews that examine potential rationales for these differences. The first theme was the formal, informal, and self-taught preparation teachers received for working with students of multicultural backgrounds. Teacher responses about training was included in this section in order to determine if teacher education and professional development had an impact on the beliefs and attitudes of the teachers. The second theme revolved around how the representation of multiculturalism in different content area classrooms reflected the attitudes of content area teachers, and how the attitudes of teachers in turn influenced the progression of multicultural students into subsequent science classes. This section also included responses from teachers when asked to estimate the demographics on ethnicity.

Teacher Education and Professional Development Influence on Beliefs and Attitudes

When asked about the training they received for working with students of multicultural backgrounds, teachers indicated that formal training was for the most part non-existent and those who felt a need to address multiculturalism had come up with their own plans or asked other teachers for advice. The interviews further indicated that the attitudes on the need for addressing multicultural differences was related to their experiences with students in the classroom. Biology and Earth science teachers voiced concerns about their levels of training and student outcomes, while chemistry and physics teachers did not see the same level of urgency.

All 12 teachers were asked if they had received formal instruction in working with students of multicultural backgrounds. Only one teacher, Emma, reported having taken any related coursework, indicating that it was a two-week unit on working with urban and multicultural students covered during her coursework on becoming a school administrator. When asked about the class, she indicated that the "the main takeaway was that students who feel different from the rest of the school or who don't personally connect with material are less likely to do well in school and more likely to drop out," adding that she felt "the class didn't spend enough time to properly address the material."

All biology teachers and Earth science teachers reported they recognized that students of different backgrounds did not perform equally and that they wanted to give all their students the best preparation possible. Five of the biology teachers and one of the Earth science teachers reported having consulted with ELL teachers in their buildings. Brooke indicated:

> I've met with the school's ELL teacher several times and we've gone over specific vocabulary strategies that I can use with the students to help them learn important terms that will appear frequently, and the teacher has also helped me to find translated copies of the textbooks that I use in my class.

Bianca and Beatrice indicated that the ELL department in their school had identified readings and short books that the ELL teachers could use in their language comprehension classes that could help support the work done in the science classes. Elise indicated that the ELL teacher also assisted in developing questions to add to her student survey and in translating the survey into multiple languages.

Badra and Blanca, who identified as Indian (Asian) and Hispanic respectively, indicated that their personal experiences shaped their attitudes on working with multicultural students. As Blanca stated:

> I know what I went through growing up isn't exactly like what students today go through, but I was one of the only Hispanic kids where we lived and I remember what it was like growing up and feeling different and it makes me feel that I need to help them even more. I try to think about the problems I had and the connections to my own life that that helped me understand. I try to share my experiences with [my students] and try to connect with

> them … to make my class feel safe and to make them want to be there… and hopefully want to learn something while they are there.

The biology and Earth science teachers all expressed sentiments aligned to Brooke's statement addressing the need for structured training:

> I wish I could get more formal training on what I should be doing...For the most part I've been trying to figure out how to support the students through trial and error. I try to think of ways to connect with them and try things out in class. Sometimes it's looking for readings in their languages or articles about where they came from. A lot of times it's asking them to share their stories related to what we are doing in class. Mostly it's checking in on them to get a reading on how well they are getting it and being flexible with when and what they have to hand in.

The chemistry and physics teachers did not express similar concerns nor demonstrated the need for more training, as expressed by Peter when he prioritized the need for professional development on curriculum and content standards:

> It would be nice to get some [professional development] on working with culture and maybe it will be more important in the future, but there's so many other things to learn about now that seem more critical to me…new content standards, creating inquiry based lessons, and bringing engineering and technology into the classroom.

Patterns of Multiculturalism in Content Areas

During the interviews, the teachers were asked about the representation of students of multicultural backgrounds in their classes and how that reflected the representation of multicultural students in their school. Biology and Earth science teachers believed that their classrooms were generally representative of the school populations in terms of cultural diversity, though they thought that the upper level classes, represented by chemistry and physics, would be predominantly White or Americanized students. Chemistry and physics teachers indicated that it was unlikely that their classes were representative of the overall school demographics, and generally agreed with Peter's assertion that "there is likely to be more diversity in Earth science and biology classes."

Table 5.1 presents demographic data of the ethnicity at the time of the interviews of the student populations at the two schools where teachers were interviewed, based on enrollment data that was collected as part of the New York State Education Department (NYSED) Student Information Repository System (New York State Education Department, 2017). This data can be found publicly on the NYSED website. The percentage of English Language Learners in the school was also included, as many references were made specifically to ELL population in the schools.

Table 5.1

Student Ethnicity Data for Schools of Teachers Interviewed

	Urban High School	Suburban High School
Black or African American	13%	18%
Hispanic or Latino	48%	16%
Asian or Native Hawaiian / Other Pacific Islander	31%	10%
White	5%	55%
Multiracial	1%	1%
English Language Learner	20%	2%

Biology and Earth science teachers in both the urban and suburban settings had fairly accurate estimations of the ethnic breakdown of the school population when compared to the figures obtained from NYSED. The estimates of the population made by Badra, Beatrice, Blanca, and Elise, the biology and Earth science teachers who were all in the urban setting, ranged between 45% and 60% Hispanic, between 25% and 33% Asian, between 15% and 20% Black, and less than 5%White, with Badra specifically acknowledging that the White students were more representative of Russian and Polish immigrants. All four teachers also assumed that approximately 25% of the students in the school were classified as ELL. Blanca indicated that her classes had a mix of students of all backgrounds, but that there may be an under-representation of native Spanish speakers because many of the students with Spanish language skills were encouraged to take biology in the bilingual sections offered in the school. Beatrice indicated that her biology classes appeared to have equal representation of the different populations in the school, but she also noted that the biology Academic Intervention Services (AIS) sections had more students of Hispanic origin. AIS classes provided an extra period of class time during the week to provide additional supports for students who were either struggling in their core biology class or had to retake state exams. Badra also indicated that the biology classes had a representative distribution, though she added that there "are many sections of ELL biology in the school with many of immigrant students enrolled."

Betty, Brooke, and Emma, the biology and Earth science teachers in the suburban setting, estimated that their classes and the school had populations of between 55% and 60% White students, between 20% and 25% Black students, between 15% and 20% Hispanic students, and about 10% Asian students. A difference presented when asked about the percentages of ELL students: the biology teachers thought the ELL students made up between 5% and 10% of the population while the Earth science teacher thought that less than 1% of the students were ELL. Betty stated that "where it used to be that you'd count the Special Ed kids in a class, now we are counting the ELL kids in the class." When asked if the ELL students made up most of the cultural diversity of the student body, Betty responded:

> They don't, but they [ELL students] are the ones that we are mostly concerned about and what we have strategies built around. The [culturally diverse] students who are not ELL seem to do fine, so we don't focus on them as much.

Both suburban teachers indicated that there were no science sections specifically designated as ELL. When asked to elaborate further on the matter, both Brooke and Betty indicated that nearly all ELL students were of Spanish origin, though there was a handful that came from Middle Eastern or Chinese backgrounds

Physics and chemistry teachers in both settings generally felt that their classes were multicultural but were less confident about knowing the overall population of the school. Both groups of teachers indicated that they did not believe that their classes may be a fair representation of the school overall. Both Phil and Peter, who taught in the suburban setting, indicted their classes were about 75% White, with the remaining 25% being mostly students of Asian background, with one or two African-American or Spanish students between the multiple classes each taught. Peter commented "I know there are more Spanish kids in the school because I hear kids talking Spanish in the hallway outside my class, but I don't have very many in my classes." When asked about ELL students, neither could identify their current students as ELL, though Phil recalled having a Chinese ELL student the previous year "mainly because [he] remember[ed] the student had received a translated edition of the state exam at the end of the year." Chris, the suburban chemistry teacher, indicated that he had never really considered the backgrounds of his students in terms of race, or their being designated as ELL, and estimated that most of the class was White, though he was not comfortable making an estimate. Cathy and Pam, who both taught in the urban setting, indicated that most of the chemistry and physics classes were Asian or Asian of Caribbean background (i.e. Guyanese or Trinidadian) with one or two Black or Hispanic students. Cathy indicated that, though she could not be sure, she thought the Black students were of African-American and not Caribbean-American descent.

Students appearing “Americanized” was a common theme when discussing the students of multicultural backgrounds in the chemistry and physics classes. When describing the multicultural students in their schools, there was a common theme among biology teachers indicating that the classes were more likely to have White students and students who had assimilated to American culture. Betty stated:

> I don’t teach chemistry or physics classes but based on when I have passed through the rooms or covered classes, I’d say those classes are mainly White or Asian and Indian. There are some African-American kids, and some Hispanic kids, but they [Hispanics students] are the ones that grew up here and are more Americanized.

Similarly when asked about upper level classes in her school setting, Blanca stated, “Many of the students who move onto chemistry classes are of Asian backgrounds, along with some of the Black students, and the Hispanic and Caribbean students who were more Americanized.” When asked to elaborate on the term “Americanized”, Betty explained that these were students who “understood pop-culture references and dressed like students on TV or in movies, were generally social, had a focus on getting into college and finding a career, and acted like the White students.” Blanca also indicated that the Americanized students were influenced by American pop-culture, and also added that they spoke English fairly fluently, were more likely to use technology and social media, and generally did not speak their home language in school nor dress in their traditional clothing.

Blanca cited an example of a student that she had worked with who she described as "able to successfully transition" from an ESL biology class into upper level classes and was doing well in physics.

> Even though she had just come from Pakistan when I had her in class, over the years [the student] stopped wearing a Hijab and started becoming more vocal and acting more like the students who had grown up in America, and I think that those behaviors made it easier for her to fit in with the students in our honors classes.

When asked about the same student, the chemistry teacher Cathy, who she had in her class at the time of the interview, indicated that she "would never had known that [the student] had not grown up in America." Chris shared that "aside from the color of their skin there really wasn't anything setting [the multicultural students] in chemistry apart from the rest of the students in the classes." Peter did note that the "Spanish and Black kids in my physics classes dress and behave just like the White kids and they do just as well [academically]."

Representation of Multiculturalism in Science Courses

How do the attitudes of teachers from different content area specialties influence the representation of multiculturalism in science courses?

As noted in the section describing representation of multicultural students in the school and the classroom, all 12 teachers indicated that the biology and Earth science classes were more likely to representative of the overall population when compared to the chemistry and physics classes. When asked about possible causes for the discrepancies in the cultural backgrounds of the students in the different science classes, a frequent topic of discussion that came up was the progression of students through the science courses. The urban and suburban schools both had similar progressions of science coursework for students with a strong filtering effect, allowing for students who were less successful to move out of the core progression at each grade in high school. As such, teachers who worked with students in the initial years of secondary school (i.e. biology and Earth science teachers) reported to have more experience with working with a wider sample of multicultural students than teachers who teacher the upper level classes (i.e. chemistry and physics).

In both high school settings, the course progression had entering ninth graders enrolled in biology classes, and most moving onto Earth science classes in their second year. In both settings, chemistry and physics represented the next sequential steps for the core progression through the core science classes and were commonly referred to the “upper level” or “upper grade” classes. When asked about the terminology, there was a similar sentiment among teachers echoing Betty’s description of “physics and chemistry are seen as harder because of the more intensive math and more theoretical material.” In both urban and suburban settings, teachers indicated that students were generally encouraged to take upper level classes but could select to step out of the progression to enroll in elective classes instead. The teachers in the suburban district indicated there were some students who took Earth science in the ninth grade because they had been accelerated into biology at the middle school level. The teachers from the urban school districts indicated biology was standard for all ninth graders, and students who may have been accelerated in middle school science were more likely to have taken Earth science prior to entering high school.

Teachers explained that the progression through the sciences had much to do with fulfillment of graduation requirements, which required a minimum one year of biological science and one year of physical science. These requirements were met for most students by completing biology and Earth science in their first two years of high school. When asked about criteria in her urban school was used for student placement into science classes after biology, Beatrice was able to give a detailed explanation of the progression:

> Most of the decision is pretty automatic. Everyone is supposed to move from biology to Earth science, but if the student has a language barrier or failed the class, they either move to an elective or repeat the class. In our school we have sections of environmental science designed specifically for ELL students. If a student placed out of ELL or is doing really well, they will get scheduled to take Earth science too. If a student passed biology but didn't pass the state test [a requirement for graduation], they take a second year of biology as part of AIS. I teach a couple of sections of AIS and those classes are mostly Hispanic or Black students. If they do really well in Earth science or get recommended by a teacher, they can go on into chemistry or physics. But if the teacher or the student's counselor is worried about possibly failing, they get put into electives until they get all their science credits for graduation. We have a lot of science electives so there's a lot of things that the students can study instead of having to fail at chemistry or physics. They can take forensics, or science in the news, or health careers, or environmental science. The electives are more flexible and don't have state exams, so the students are more likely to pass and to have a better experience with science.

Badra also commented on the urban progression, and included a scenario of what happened when the school attempted to change the progression:

> Students who do well in biology tend to do well in Earth science and then move through chemistry and physics. A lot of the students don't want to take science. A few years ago, we tried to have everyone in Earth science move on to chemistry. We had bad results and a lot of students failing. The failures didn't look good for the school and made the

> students dislike science even more, so the school stopped trying to make everyone take chemistry and only moved the students who were doing really well into chemistry and physics.

Badra further indicated that many of the Spanish, Black, and ELL students who were removed from the progression into chemistry had not shown high proficiency in English. She then continued about the progression:

> Most of the students don't go all the way to physics, even the stronger students. Some of the students in my AP [Advanced Placement] Biology class are taking it with physics and a lot take [AP Biology] instead of physics. I tell my students who are doing well that they need to take chemistry and physics. I wish we had more sections for students to take, but at least there are some opportunities for the students that are doing very well.

Beatrice and Badra indicated that though there were supports and AIS classes in place for biology. There were neither core science classes nor support classes designated for ELL students after biology. They also indicated not all ELL students were programmed to take Earth science after biology and that most went on to take electives such health careers or environmental science. Badra stated that if a student performed well in an ELL section of biology, they may be recommended to go into non-ELL Earth science and from there onto chemistry, but these cases were rare.

When asked about the progression of courses that students followed in the suburban setting Betty indicated a similar overall progression though there was greater emphasis and expectation to move through chemistry. However, the ELL students were the ones most likely to veer from the progression:

> Almost all of our students take [biology], then Earth science, and then chemistry. Most students go onto take physics as well, though there are some students that opt to take electives instead of physics. Most of the ELL students will move on to take Earth science unless they end up repeating biology. It's what pretty much everyone does, but what happens after that may depend on how well they do. They may go on to chemistry, but if they have been having language issues or have issues with attendance, they will probably take electives or basic science courses.

When asked about her thoughts on the science preparation received by the multicultural students outside of those in ELL, Betty said:

> If they grew up here or were able to adapt quickly, they will do fine and take chemistry, and probably physics. But I don't really think we are serving the students who can't fit in very well. … I mean those who don't generally act like suburban White students. We have a large mix of different races and students from different parts of the town. And there are groups of Black or Spanish students who are more, for lack of a better word, 'urban' and I have a lot of them in my elective classes... a lot of them either did poorly in chemistry or dropped it. And I don't think a lot of them take physics after they finish chemistry. I guess there's a sense that they may have a hard time with the math and the vocabulary and there really aren't any AIS supports in place after Earth science. So, it's better for them to be able to take other science classes that they will have a better chance of doing well in.

When asked if that same pattern held true for White students, Betty stated, "I guess it is the same, but just based on my elective classes there are more students of color." Brooke echoed those sentiments adding, "A lot of the Spanish students end up enrolling in my AIS classes to prepare to retake the state exams, after they pass some of them go into our unified science classes, or forensics, or marine biology."

Biology teachers saw themselves in the role of supporting students of all backgrounds and helping transition most on to take Earth science. And though the Earth science teachers also saw a majority of the students in the school, in both the urban and suburban settings, they ultimately also had a role of gatekeeper and described a pressure on teachers and schools for students to have high grades and for ensuring that students receive the credits needed for graduation. Emma stated:

> The [upper level] courses are based around exams that test state standards which are more intensive and can be difficult for students that had not done well in biology or Earth science … it serves everyone better for students who already struggled with science classes or state exams to take electives instead of continuing to struggle in upper level classes.

Emma explained that once students were nearing the completion of Earth science there was a selection process where students had an opportunity to select the class they would take in the following year:

> I have an opportunity to make suggestions based on how the students are doing, but usually the students are pretty good at judging if they are ready for more difficult courses like chemistry. We also discuss options in electives like marine biology, forensics, and environmental science. If they want to pursue science after high school, I suggest they take chemistry but generally leave the decision to the students and their parents.

When asked to elaborate on whether there might be a discrepancy in the numbers of White students that pass onto chemistry in comparison to the students of multicultural backgrounds, Emma stated:

> There's definitely a difference. Most of the White students have parents that are pushing them to go to four-year colleges and so they need chemistry to be in a better position when they apply. Same thing for the Asian students and for some of the Black or Hispanic students. If the parents want the kid to go to chemistry, they will push the guidance counselors to move [the student] onto chemistry. I know because a lot of them will contact me as well. I don't get as many calls from the Hispanic and Black parents, so I image the guidance counselors don't as well. So, the kids go on to take an elective instead.

When asked about her feelings about the practice, Emma reiterated that it was not her place to make the decision and stated:

> I think I'd rather they get into a science where they will do well and enjoy being there. And frankly I think that the forensics classes and anatomy classes are a lot more engaging for the students who didn't excel in Earth science than chemistry or physics would be

Elise, who taught in the urban setting similarly felt that moving out of the progression into chemistry and physics could be in the best interest of the student and would only try to influence a decision if the student was performing well in class:

> Coming out of Earth science is usually the first chance students have to make a choice in science. They all had to take biology and Earth science, but now have the option to take electives. Most of that decision is made by the students discussing their plans with parents and guidance counselors. If a student is doing really well in my class and I find

out they didn't select to go into chemistry, I might have a talk with him or her, but it's not an easy course and if the student hasn't shown an ability to work hard and synthesize a lot of reading and lab work I don't want to set them up for failure… They are better off tasting success in environmental science.

When asked if a student's cultural background could impact readiness for pursuing rigorous classes, Emma appeared to recognize that there may be different expectations based on race but became uncomfortable with the conversation and indicated that she was more comfortable not being part of the decision of how a student progresses in science after her class:

> Moving into higher level science has more to do with the grades that students are earning than their race or cultural background. Of course, a stronger performing minority student will do better than a weaker performing White student, and I'm not going to hold either student back. I can't say I have the data to speak about it but it's possible that the weaker White student, or their parents, may be more willing to risk doing poorly in chemistry and so may select chemistry over an elective, but on the flip side I don't want to push a student, minority or not, into a class they don't think they are ready for. Once they are past Earth science a student can drop a class if they think it's too hard but that can be seen as a negative for the student. That's really a personal decision that can affect the kid down the line and frankly that's a conversation the student should have with the guidance counsellor.

Both chemistry teachers indicated that students had to have been successful in science previously to be enrolled in chemistry and attributed part of the decision to recommendations of Earth science teachers, who were previously noted that they preferred to not be a part of the decision. Neither teacher however addressed the cultural backgrounds of the students as indicators for their progress through chemistry. Cathy commented:

> I really don't have much of a hand in who gets into chemistry that decision was made by the Earth science teachers and the guidance counselors… generally all the students in the class value learning and are dedicated to doing well. Based on the nature of the school the students are all from multicultural backgrounds, mostly of Asian or Caribbean Asian descent, but their skills and abilities seem to go beyond cultural barriers.

She went on to explain that enrolling in chemistry was generally a good indicator of moving into physics or other upper level science classes:

> Generally, most of the students in chemistry are qualified to move onto physics. Some don't and take Advance Placement classes instead and others were seniors while enrolled in chemistry and graduated before they could move on.

Chris commented that he didn't understand why a student's cultural background should impact performance in chemistry focusing on the course as inherently objective:

> The students in my chemistry classes are expected to focus on the chemistry regardless of their background race or ethnicity. Chemistry is pretty much the same wherever you go and I focus on the content more than anything else ... much of what I teach is abstract and based on math. I guess kids from some backgrounds may be better or worse at math than others or may put more emphasis on learning than others, but that's not really all that different whether a student comes from a White, Black or Asian household. No matter where they're from there's students who do well and students who don't. I have had successful Black students in my classes who have gone on to take physics and AP courses and I have had unsuccessful White students who I recommend should drop the

course and move into electives. But it is pretty rare for a student who isn't ready for chemistry to get to this point.

When asked about progressing from chemistry to physics, Chris' practices aligned with recommendations being based purely on performance:

> I have the same expectations of all my students and a very flat outlook on recommending students for physics. If they were able to maintain a 90 or higher in chemistry, the students should be taking physics. Anything else, and they should consider electives instead.

All three physics teachers indicated that, with the exception of the occasional student who struggles in the class, they had not given much thought to the progression of students through the other sciences to physics, stating that the decisions about progression have been made prior to their having the students in their classes.

5.3 Main Findings from Quantitative Analysis

Figure 5.1 summarizes the main findings from the qualitative analysis of interview data linked to Research Question 1, which addressed the presence of differences in attitudes and beliefs of in-service science teachers of different content areas in regard to multiculturalism in the science classroom.

Figure 5.1

Summary of Main Findings of Qualitative Analysis on Differences in Attitudes and Beliefs of In-service Science Teachers

- All teachers report having beliefs that cultural diversity is a positive.

- Biology and Earth science teachers' responses indicate attitudes that place greater emphasis on the need for identifying multicultural students

- Responses of biology and Earth science teachers indicate that when asked to discuss multicultural students they focus mostly on the needs and experiences of English Language Learners (ELL), even when ELLs are not a large part of the multicultural population in their school.

- Biology and Earth science teachers generally express negative attitudes about the performance of multicultural students in their classes.
- Physics and chemistry teachers generally express attitudes that multicultural students in their class do as well if not better than White counterparts.

Figure 5.2 summarizes the main findings from the qualitative analysis of interview data linked to Research Question 2, which addressed underlying factors that result in differences in attitudes and beliefs of in-service science teachers of different content areas in regard to multiculturalism in the science classroom.

Figure 5.2

Summary of Main Findings of Qualitative Analysis on Underlying Factors that Attribute to Differences in Attitudes and Beliefs of In-service Science Teachers

- Formal preparation regarding working with multicultural students virtually non-existent for in-service teachers
    - Biology and Earth science teacher feel a need exists for professional development on culturally responsive teaching
    - Chemistry and physics teachers do not feel there is a need for professional development on culturally responsive teaching

- Teachers report that students of multicultural backgrounds struggle more in science classes and are frequently encouraged to take electives as part of science course progression instead of chemistry and/or physics
    - “Americanized” students more likely to do well and progress into chemistry, physics and upper level classes.

- Teachers report that multicultural students in chemistry and physics classes don’t represent overall demographics of the schools.
    - Chemistry and physics teachers tend to only see those multicultural students who are doing well in science.

Chapter 6: Discussion, Implications, and Conclusion

The purpose of this study is to examine the beliefs and attitudes of in-service secondary science teachers on multiculturalism in the science classroom to determine if there are differences based on content area specialization and to explore underlying phenomenon that might contribute to any identified differences. The study focuses on two research questions which are discussed sequentially. The discussion will also discuss implications of study in the context of teacher education about multiculturalism and elements of Critical Race Theory that should be addressed in teacher education.

It is my belief as a researcher, and teacher supervisor, that understanding the beliefs and attitudes of in-service teachers in regard to working with multicultural students is an essential step in developing professional development opportunities that are meaningful for teachers. Meaningful professional development can help teachers to better support students of multicultural background, and in turn allow more students access to upper lever science courses and eventual college and career readiness to enter STEM fields.

As a corollary, the discussion will also examine the use of network correlation analysis as a tool for between group analyses.

6.1 Research Question 1 Major Findings

Research Question 1 asks "How can we characterize differences in the beliefs and attitudes of in-service secondary science teachers of different content specialties (i.e., biology, chemistry, physics, and Earth science) towards working with multicultural students in secondary science classroom settings?" To answer the question the study triangulates the data from statistical comparative analysis of responses to survey items, network correlation diagrams, patterns in Likert responses, and themes that emerged from teacher interviews.

Overall Similarities and Differences in the Patterns of Beliefs and Attitudes of Science Teachers

A review of the results of both quantitative and qualitative analysis suggests that there are many similarities in the attitudes and views expressed by the science teachers across all disciplines. The results of statistical comparison analysis, using step-wise implementation of Kruskal-Wallis testing and Mann-Whitney U analysis, indicate that the views and attitudes of science teachers are relatively consistent. The analysis indicates that there are significant differences for only five of the 54 items on the Survey of Multiculturalism in the Science Classroom (SMSC). Examination of the Likert responses indicate that on the whole science teachers show consistently high agreement in their beliefs about the importance of celebrating cultural diversity. This is supported by the network correlation diagrams, where Item 1 from the SMSC (It is important to celebrate cultural diversity) is represented by either the central node or a major node in the diagrams of responses for all teachers and groups by content area. It is further supported by the interviews as the responses of all 12 participants indicate positive impacts of having exposure to diverse cultures.

Analysis of the results indicate that the beliefs and attitudes of physics teachers demonstrate the greatest variance from those of other science teachers. The statistical comparison tests indicate that physics teachers show statistical differences with at least one other group of science teachers for all five of the items that show the presence of statistical differences: physics teachers show statistical differences with biology teachers for all five items, chemistry teachers for four items, and Earth science teachers for two items. In comparison, there exist relatively little statistical differences between the other groupings of content area teachers: biology and Earth science teachers show statistical differences for only one item, chemistry and

Earth science teachers show statistical differences for only one item, and biology and chemistry teacher do not show statistical differences for any of the items. A comparison of network correlation diagrams reveals higher numbers of nodes and linkages present in the diagram representing physics teachers in comparison to the network diagrams of other disciplines. Responses to the interviews also indicate difference, as the responses of physics teachers place the least emphasis on the importance of identifying the cultural differences of their students and demonstrate that they are the likely to make changes to content to address the needs of students of multicultural backgrounds.

Differences in the Correlations of Beliefs and Attitudes

Examination of network correlation diagrams indicate strong correlations among fewer items for biology and Earth science teachers and stronger correlations among more items for physics and chemistry teachers, as represented by the number of nodes and linkages present. It is of particular note, that the nodes that are present in the network correlation diagrams of biology and Earth science teachers predominantly represent the internal beliefs that teachers hold about the importance of multiculturalism. In comparison the nodes in the network diagrams of physics and chemistry teachers included the items that represented both attitudes and beliefs, with the diagram for physics teachers having nodes representing 17 or the 18 possible items. This would seem to indicate that whereas the internal beliefs of science teachers are relatively consistent, there is less correlation between the beliefs and attitudes expressed by biology and Earth science teachers in comparison to the correlations between the beliefs and attitudes of physics teachers. This observation led to a question of why such a difference exits, which will be revisited later in the discussion.

Beliefs about Benefits of Multiculturalism

The data from the study indicates that science teachers hold positive beliefs about multiculturalism. Teachers show high percentage agreement with survey Item 1 (It is important to celebrate cultural diversity), Item 3 (It is important to recognize the contributions different cultures have made to the culture of the United States.), Item 6 (Students benefit from having a basic understanding of diverse cultures), and Item 12 (Teachers benefit from having a basic understanding of diverse cultures). These findings are consistent with statements made during interviews about the positive implications of multiculturalism such as exposure to more ideas, experiences, and different points of view.

Impacts of Cultural Differences

The analysis indicates that there is general agreement among science teachers that the cultural backgrounds of students can advantage some groups over others. Survey data indicates general agreement among all content area groups for Item 22 (Cultural norms in America advantage certain populations over others) and Item 23 (Science curriculum generally reflects a modern Western / Eurocentric perspective). Biology and Earth science teacher responses during the interview address how the experiences of students of multicultural backgrounds can limit the understanding of certain skills or content, necessitating the use of strategies to either make connections to parallel experiences or having to make time during the course of the curriculum to expose them to the experiences. This is a theme that does not manifest in the interviews with chemistry and physics teachers, who indicate little necessity to address the cultural backgrounds of their students.

Comparing Beliefs and Attitudes on the Identification of Multicultural Students

Though there is general agreement that cultural differences can impact student performance and success in science, survey responses to Item 11 (It is important to identify the cultural backgrounds of my students) indicate that biology and Earth science teachers see the identification of multicultural students as more important than chemistry and physics teachers. This difference is supported by the interview data, as biology and Earth science teachers indicate that the identification of a student's cultural backgrounds allows for modifications in instruction to address the differences that manifest due to the needs, prior experiences, or motivations of different multicultural groups. In comparison chemistry and physics teachers place less emphasis on the identification of the backgrounds of multicultural students and or the modification of instruction to accommodate the potential needs of their multicultural students.

Of notable interest are the differences in responses to survey Item 38 (Multicultural students are as likely to succeed in upper level and honors classes) with which biology and Earth science teachers have a higher percentage agreement in comparison to chemistry and physics teachers. As noted in the comparisons above, biology and Earth science teachers are consistently more conscious of the needs of multicultural students and indicate the need to make specific accommodations in planning to address those needs. Perhaps it is because of their recognition of the disadvantages faced by multicultural students that biology and Earth science teachers expect a lower likelihood for multicultural students to achieve success as they progress into chemistry, physics or other upper level courses. Although physics and chemistry teachers recognize that not all multicultural students are represented in upper level courses, they have expressed that they do not view cultural backgrounds of students as an issue of consideration. This has been demonstrated by their generalizing the success of specific multicultural groups (i.e. Asian) to all cultural backgrounds or citing specific counter-narrative examples of students of multicultural backgrounds performing at the same levels or exceeding their White peers (i.e. the Hispanic immigrant student who went on to become valedictorian).

6.2 Research Question 2 Major Findings

Stemming from the differences identified in Research Question 1, Research Question 2 asks, "What underlying factors attribute to the patterns of differences when comparing the beliefs and attitudes of secondary science teachers of different content specializations in regard to multiculturalism in the science classroom?" As indicated in the previous section, though there is considerable agreement on multiculturalism being viewed as a positive by all teachers, there are differences in several of the responses of physics teachers, and to some respect chemistry teachers, with those of biology and Earth science teachers.

Teacher Preparation

Analysis of the interviews indicates that professional development or education on working with multicultural students does not greatly attribute to the differences in views between teachers of different content area groups. This is mainly because most of the teachers report the lack of any formalized education or professional development for working with students of multicultural backgrounds. The biology and Earth science teachers acknowledge that there are deficiencies in the experiences, skills, and content of many multicultural students that impede their success in science. The teachers also indicate that, because of their perceived need, they have sought out informal training from others or have developed their own practices to accommodate the needs of their students. Conversely, physics and chemistry teachers generally do not see a need to address cultural differences in their classes, and therefore do not see a need for education or professional development.

Furthermore, because of the lack of formal training and preparation, the strategies that teachers use to work with students of multicultural backgrounds indicate that most teachers are operating at rudimentary levels in regard to the spectrum of ideologies for teaching multicultural students (see Fig. 2.1). Based on the results of the interviews chemistry and physics teachers are likely to acknowledge diversity without initiating meaningful action to either understand the needs of their multicultural students or develop culturally responsive strategies. Several teachers indicate that multicultural students who are more likely to be successful are the ones who have become “Americanized” which indicating an attitude favoring assimilation to cultural norms as the pathway to success. At best some teachers indicated levels of cultural responsiveness by including cultural aspects (i.e. cuisine of the students in discussing nutrition), calling on past experiences (i.e. student knowledge of the geographic regions students are informed about), and being culturally sensitive (making accommodations for cultural practices) part of their instructional practices.

Representation of Multicultural Students in the Science Progression

Teacher experience appears to be a key factor that leads to the differences in the views and attitudes of science teachers in regard to working with multicultural students. This experience seems most directly ties to the representation of multicultural students in the different levels of progression through the pathway of secondary science courses. This progression also includes the potential attrition of students into electives and away from the traditional pathway of biology, Earth science, chemistry, and physics established by the National Education Association and the Committee or Ten in the late 1800’s. Students in both school settings where teachers were interviewed are required to complete biology or Earth science in the beginning of their high school career before moving on to chemistry, and eventually physics. Teacher reports indicate that while all students enroll in the required biology and Earth science classes, not all students proceed into chemistry and physics. As a result, the demographics of chemistry and physics classes underrepresent the multicultural demographics of their schools. Teachers also report that of the multicultural students that do move onto chemistry and physics, most can be described as exceptional students, “Americanized”, or both. As such most chemistry and physics teachers do not interact with the same cross-section of multicultural students as do the biology and Earth science students in the same locations.

Biology and Earth science teachers report that course progression is primarily based on current performance and the successful completion of graduation requirements, rather than adherence to the progression into sections of chemistry and physics. In both schools, the graduation requirements require completion of biology, Earth science and an additional science that can be chemistry, physics, or an elective. Students who do not perform exceptionally well as more likely to be promoted into remedial courses or elective courses that allow teacher flexibility of curriculum. According to teacher reports, Black, Hispanic, and immigrant students are more likely to progress into electives, while White and Asian students are more likely to be promoted into chemistry and physics.

The attrition of multicultural students before progressing into chemistry and physics classes explain why teachers of those subjects do not feel the need to address, or be educated, on the needs of students for multicultural backgrounds. Whereas teachers of biology and Earth science interact with students of all cultural backgrounds and academic levels, chemistry and physics teachers regularly interact only with students who are better equipped for the demands of rigorous curriculum.

The reports of the chemistry, Earth science and physics teachers in the urban setting all reference the same immigrant Hispanic valedictorian as a counter narrative and proof that students of multicultural backgrounds can be successful regardless of the difficulties they may have to face. Although a feat to be celebrated, the single counter narrative potentially undermines the difficulties of many other students from culturally diverse backgrounds.

This intersection of lack of exposure to most multicultural students, coupled with memorable exposure to students who serve as a counter narrative could lead teachers of chemistry and physics to not focus on the needs and accommodations for multicultural students. This represents the potential for a vicious cycle, where the perceived lack of need for training on issues pertaining to multicultural students may in turn result in perpetuating the difficulties and eventual attrition of multicultural students who may be selected to progress into chemistry and physics courses.

6.3 Implications

Need for Teacher Education on Working with Multicultural Students

The results of this study indicate a dire need for teacher education and professional development that focuses on multiculturalism for in-service science teachers of all content area specialties. A review of literature on diversity in teacher education reveals that there is expanding research on culturally responsive teaching that aims at making curricular and instructional adjustments to address the real and perceived differences that can negatively impact the success of multicultural students (Mensah, 2011). Over the past two decades an awareness of the impacts of cultural differences has broadened (Manning et al, 2017), representation of students from multicultural backgrounds in the school population has increased (Vespa, 2017), national standards have looked to address the need to make science accessible to all students (Lee et al, 2014), and teacher educators have developed pedagogies to specifically address cultural diversity (Mensah & Larson, 2018). During this time, strategies for working with students of multicultural backgrounds have progressed from lack of acknowledgement, to assimilation, to introduction of multicultural elements in curriculum, to pedagogy designed to focus on the needs of multicultural students, and ultimately pedagogy designed to allow multicultural students to become agents of change (Mensah, 2019).

However, the progress made over the past two decades is not readily visible in classrooms working with multicultural students. Although the in-service teachers in the study ranged from four years to thirty years of service, none report any formalized education or professional development in regards to multiculturalism in the science classroom and only teachers teaching courses required for graduation (i.e. biology and Earth science) report a need for developing strategies for working with multicultural students. Comments from teachers who are trying to understand the needs of multicultural students, focus on the need for identifying cultural backgrounds in order to differentiate their planning, also made allusions stereotyping of students based on background and to having lower expectations for certain populations of students. Teachers also report that assimilation (i.e. “Americanization”) is still a major indicator of whether a student will be successful in science, and subsequently be promoted chemistry and physics.

Conversely in-service teachers, who do not typically see students who they perceive as having cultural differences do not see the need for training and professional development. As a result, students of multicultural backgrounds who have difficulty due to linguistic, cultural, or experiential barriers are moved out of the progression to chemistry and physics, because of the perception of the classes as being too difficult and the lack of training that teachers of those courses have for accommodating the needs of multicultural students.

Though the motivation to receive preparation and professional development on working with students of multicultural backgrounds does not seem uniform across all content area disciplines of science, there is acknowledgement for the need among biology and Earth science teachers. Coupling the acknowledgement of need among some teachers with the demonstrated agreement among all science teachers about the positive benefits of multiculturalism provides a platform for inclusion of the topic in ongoing science teacher professional development.

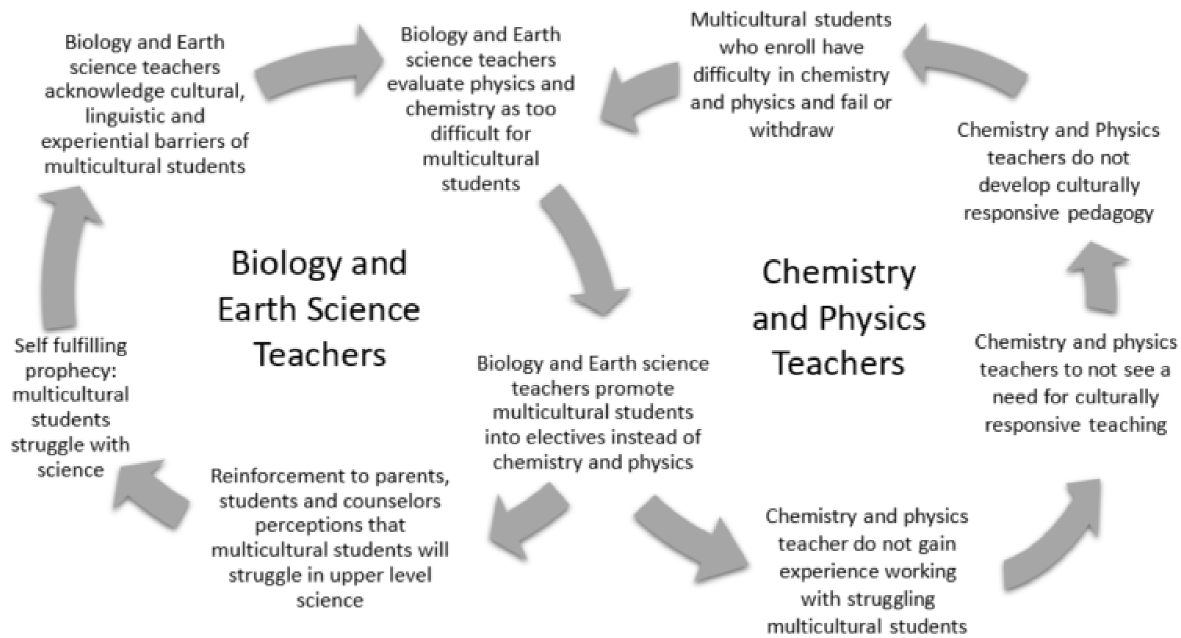
Recognizing Elements of Critical Race Theory as Part of Science Education

This study uses a Critical Race Theory lens as it examines questions related to race, power, and equity in science education. The interviews reveal strong implications that the elements of Critical Race Theory should be addressed in future work on teacher education and professional development for in-service science teachers. Responses during the interviews indicate acknowledgement of the perpetuation of systemic inequities, the use of counter narratives to deemphasize inequities, and oversimplifications stemming from intersectionality of groups.

In order to develop their culturally responsive instructional practices, the teachers must first acknowledge their part in the cyclical phenomenon perpetuating systemic inequity (see figure 6.1). Biology and Earth science teachers acknowledge that the existence of cultural, linguistic, and experiential barriers can result in students struggling with the material. They also indicate that many of the strategies they implement focus on overcoming such barriers and the desire to give students a successful experience in science. However, the same teachers frequently see electives as the next step in students' progression through science because of their attitude that students who have to overcome cultural barriers will successful in electives in lieu of chemistry and physics.

Figure 6.1

Systems Impacting Science Progression of Multicultural Students



Though the teachers see themselves as looking out for the best interests of the students, the teachers unintentionally reinforce to students, parents, and counselors that students with cultural differences are less likely to be successful in chemistry and physics, resulting in the creation of alternative progressions in science and further solidifying a culture that sees students of multicultural backgrounds as unlikely to be successful in upper level science chemistry, physics and upper level science classes. This filtering process also impacts chemistry and physics teachers who are not confronted with the opportunity to work with students of multicultural backgrounds, resulting in not developing their culturally responsive pedagogies that could potentially assist future students.

A second element that should be addressed in teacher education is the use of counter narratives to indicate there are no issues requiring the further development of culturally responsive pedagogies. Multiple physics and chemistry teachers state they have Black and Hispanic students who perform as well in their classes as the White and Asian students. This focus on students that fit a counter narrative to that of Black, Hispanic, and immigrant students struggling in science can also result in a false belief that the progression through the sciences has been equitable and that all students of Black, Hispanic, or immigrant backgrounds have had the same opportunities as all other students.

The third element to address is the generalization of the experiences of students of multicultural backgrounds based on intersections of groups. It is evident form the interviews that many, if not all, teachers generalize the experiences of ELL (English Language Learner) students to represent the experiences of all students of multicultural backgrounds. By doing so the teachers equate the linguistic, cultural, and experiential differences of recent immigrant students to those of all multicultural students, including Black and Hispanic students who may have experienced inequity though having grown up as Americans, Asian and Caribbean students who did not have linguistic concerns but had cultural and experiential differences, and middle Eastern students whose religious beliefs may have clashed with what are seen as standard practices in science classrooms. In addressing overgeneralization, teachers should be cognizant that in the case of students of multicultural backgrounds "one size does not fit all".

Use of Network Correlation Diagrams for Intra-group Comparisons

This study uses the relatively novel technique of network correlation analysis (Anderson, 2015) as part of its statistical analysis procedures. At the time of this study, prior research studies using the analysis technique predominantly compared results of single groups across pre and post testing (Varthis & Anderson, 2018). As outlined at the beginning of this chapter, the use of network correlation analysis reveals comparative differences between the beliefs and attitudes of teachers of physics and teachers of other science disciplines. These findings are substantiated through the analysis of teacher interviews and are consistent with the findings of the statistical comparison testing using Kruskal-Wallis and Mann-Whitney U analysis. The network correlation analysis also demonstrates the similarities in beliefs and attitudes of biology and Earth science teachers, which is also consistent with the teacher reports taken during interviews. As such the results of network correlation analysis was consistent with other measures in the study, indicating its potential use as tool for confirming the validity of results in studies that investigate intergroup comparisons.

Limitations and Recommendations for Further Research

The main goal of this study is to determine if there are differences in the beliefs and attitudes of in-service science teachers specializing in different content areas and to determine how those differences may attribute to the performance of students of multicultural backgrounds in the sciences. This study uses a mixed methods approach with a cross-sectional survey with follow-up using a series of individual interviews. A grounded theory approach allows exploration of emerging themes that come from the responses in the interviews. With an ultimate goal of developing a deep understanding of the views and attitudes of the participants, future work would benefit from using a constructivist grounded theory approach and using multiple interviews with a smaller sample of participants in order to review, analyze, and construct the underlying meanings with the participants (Charmaz, 2006). Doing so would also benefit the field of science education by expanding the limitations of a single measure taken during a cross-sectional study and expanding to an investigation of how metacognitive analysis conducted over time and with multiple conversations could ultimately lead to changes in the attitudes and beliefs of the participants.

One of the main findings that emerges from the analysis is the difference in correlation networks for teachers of different subject specialties between items representing beliefs and items representing attitudes, which aligned with findings from the interviews. However, it should be noted that, although certain statements in the survey aligned with the construct of beliefs and other items aligned with the construct if attitude, the SMSC is not designed to differentiate between attitudes and beliefs. As such there are opportunities for developing further studies to specifically address differences between attitudes and beliefs.

In order to make comparisons between groups, teachers were separated based on certification area, and attention was given to where introductory classes for those classes fall in context of the traditional science progression (i.e., biology and Earth science represent the first classes students must complete, then students enroll in chemistry and physics classes after having completed biology and Earth science). In doing so the study did not take into great consideration interactions that may have resulted from participants teaching classes at both the introductory and advanced levels (i.e., Badra identified that she taught introductory biology to high school underclassmen and college level biology to upperclassmen), and if instructional strategies adapted in the context of teaching one level could impact teaching at other levels. The study also did not take into consideration interactions that may have resulted from teachers who have taught outside their primary area of certification (i.e., Peter identified himself as primarily a physics teacher but had indicated that he was sometimes asked to teach sections of chemistry as well, and Pam identified herself as a physics teacher but indicated that she had also taught sections of biology). Future studies could examine if and how a teacher's experience working with multicultural students in the context of introductory classes in biology or Earth science impact the same teacher's interactions with multicultural students in upper level classes, whether within the same subject or different subjects. Additionally, although none of the teachers in the study identified themselves as working in systems that utilize programs such as Physics First (Liang et al., 2006) which breaks away from the traditional sequence of classes. This creates an opportunity to compare if there are differences in the attitudes and beliefs on multiculturalism of teachers of the same subject areas in traditional progressions to those who teach in non-traditional progressions.

This study to uses a large survey response to generalize about the attitudes and beliefs of science teachers towards multiculturalism. It is recognized that in doing so, the study combines what could be nuanced differences in attitudes and beliefs towards different multicultural groups into one larger category. Critical Race Theory has branched in different directions to recognize the varied needs of different cultural and ethnic groups: Critical Race Feminism (Wing, 1997) studies issues specific to minority females, LatCrit (Solorzano & Yosso, 2001) studies issues specific to Hispanic populations, TribalCrit (Brayboy, 2005) studies issues specific to Native Americans, AsianCrit (Museus & Iftikar, 2013) studies experiences of Asian Americans, DesiCrit (Harpalani, 2013) studies issues specific to South Asian Americans, and Second Wave Whiteness (Jupp, Berry & Lensmire, 2016) studies the experiences of white immigrant groups.

Christine Sleeter (2018) identifies that with regards to teacher education, the very term "multiculturalism" has become nebulous and that teachers need to refocus on opening dialogs with the marginalized members of their respective communities. Aligned to this thinking, future studies should investigate beliefs and attitudes about experiences with specific multicultural groups (i.e. ELL students, Black students, Latinx students, Asian students, immigrant students) in order focus on the specific needs of those populations in science classrooms.

Similarly, there is a concern as to whether the generalized nature of the study would conflate possible differences and interactions based on the setting of the school (i.e. urban, suburban, or rural) and resulting differences in racial, ethnic, social, or economic demographics. As such, future studies could benefit from examining the views and attitudes of science teachers, as well as the progression, and potential attrition, of students in science classes for specific school settings in order to tailor teacher education or professional development for the demographics of particular areas.

This study examines science teachers' perspectives when delving into both the attitudes and beliefs regarding working with multicultural students and the paths that multicultural students take through different science courses over time. Another avenue for future studies would be to examine these same aspects from students' points of view and to develop an understanding of the attitudes and beliefs of students in a multicultural setting, students' perceptions about how they feel their different science education experiences connect to the content, the classroom, their science teachers, and their viewpoints on the rigor of science classes and their goals for what classes they would take if given full choice in the matter.

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Appendix A

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TEACHERS COLLEGE
COLUMBIA UNIVERSITY

Teachers College IRB *Exempt Study Approval*

To: Samir Biswas
From: Curt Naser, TC IRB Coordinator
Subject: IRB Approval: 16-362 Protocol
Date: 06/05/2016

Thank you for submitting your study entitled, "*Exploration of in-service teacher views on multi-culturalism in science education*;" the IRB has determined that your study is **Exempt** from committee review (Category **2**) on 06/05/2016.

Please keep in mind that the IRB Committee must be contacted if there are any changes to your research protocol. The number assigned to your protocol is **16-362**. Feel free to contact the IRB Office by using the "Messages" option in the electronic Mentor IRB system if you have any questions about this protocol.

Please note that your interview consent form bears an official IRB authorization stamp and is attached to this email. As the consent for the survey portion of the study will be conducted online, a stamped copy of that form is not provided here. Further, all research recruitment materials must include the study's IRB-approved protocol number. You can retrieve a PDF copy of this approval letter from the Mentor site.

Best wishes for your research work.

Sincerely,
Curt Naser, Ph.D.
TC IRB Coordinator
curtn@axiomeducation.com

Attachments:
- Biswas - Phase 2 - Informed Consent - Inte.pdf

Appendix B

Informed Consent

Teachers College, Columbia University
525 West 120th Street
New York NY 10027
212 678 3000

INFORMED CONSENT

Protocol Title: Exploration of In-Service Teacher Views on Multiculturalism in Science

Classrooms: Online Survey Consent

Principal Investigator: Samir Biswas, Teachers College 917-992-5049

INTRODUCTION

You are being invited to participate in this research study called "Exploration of In-Service Teacher Views on Multiculturalism in Science Classrooms." You may qualify to take part in this research study because you are a practicing science educator and are over 18 years old**.** Approximately 200 people will participate in this study and it will take 30-45 minutes of your time to complete.

WHY IS THIS STUDY BEING DONE?

Work in the field of science education has illustrated that differences between student home culture and the culture of the classroom has impacts on their engagement and achievement in science. This study is being done to determine the views of in-service educators towards multiculturalism in the classroom setting, and the practices of in-service teachers that may impact students from diverse cultural backgrounds. The study will examine if there are existing differences based on educator's subject of specializations (biology, chemistry, Earth science, physics, etc.) in regards to these views and practices.

WHAT WILL I BE ASKED TO DO IF I AGREE TO TAKE PART IN THIS STUDY?

If you decide to participate, you will complete an online questionnaire that will take approximately 25 to 30 minutes**.** At the end of the questionnaire participants have the option to volunteer for further study on the topic of multiculturalism in science classrooms through interviews. Participants who volunteer to be interviewed will be directed to a separate survey to collect contact information. Participation in the interviews is not required for participation in the initial survey.

It is recognized that cultural diversity, multiculturalism, and the related issues of race, ethnicity, social status, and access to resources may present topics of sensitivity. As such participants will be given the opportunity to omit or bypass questions that they are uncomfortable answering, or if necessary terminate surveys should participants deem it necessary to do so.

WHAT POSSIBLE RISKS OR DISCOMFORTS CAN I EXPECT FROM TAKING PART IN THIS STUDY?

This is a minimal risk study, which means the harms or discomforts that you may experience are not greater than you would ordinarily encounter in daily life while taking routine physical or psychological examinations or tests. Although there are no physical risks for participants in this study, it is recognized that the discussion of cultural diversity, multiculturalism, and the related issues of race, ethnicity, social status, and access to resources may present topics of sensitivity. You will have the opportunity to omit or bypass questions that they are uncomfortable answering, or if necessary terminate any interviews or surveys should they deem it necessary to do so. You can stop participating in the study at any time without penalty. You might feel concerned that things you say might get back to your principal.

The principal investigator is taking precautions to keep your information confidential and prevent anyone from discovering or guessing your identity. Data from the survey will be collected anonymously, and all information will be kept on a password protected computer and locked in a file drawer.

WHAT POSSIBLE BENEFITS CAN I EXPECT FROM TAKING PART IN THIS STUDY?

There is no direct benefit to you for participating in this study. Participation may benefit the field of teacher education to better understand the best way to prepare science educators.

WILL I BE PAID FOR BEING IN THIS STUDY?

You will not be paid to participate and there are no costs to you for taking part in this study.

WHEN IS THE STUDY OVER? CAN I LEAVE THE STUDY BEFORE IT ENDS?

The study is over when you have completed the survey. However, you can leave the study at any time even if you haven’t finished.

PROTECTION OF YOUR CONFIDENTIALITY

The investigator will keep all written materials locked in a desk drawer in a locked office. Any electronic or digital information will be stored on a computer that is password protected. Regulations require that research data be kept for at least three years.

HOW WILL THE RESULTS BE USED?

The results of this study will contribute to dissertation work being conducted by the primary researcher. The work may be published in journals and presented at academic conferences. Your name or any identifying information about you will not be published.

WHO CAN ANSWER MY QUESTIONS ABOUT THIS STUDY?

If you have any questions about taking part in this research study, you should contact the principal investigator, Samir Biswas, at 917-992-5049 or at scb2163@tc.columbia.edu You can also contact the faculty advisor, Dr. Felicia Mensah at fm2140@tc.columbia.edu.)

If you have questions or concerns about your rights as a research subject, you should contact the Institutional Review Board (IRB) (the human research ethics committee) at 212-678-4105 or email IRB@tc.edu. Or you can write to the IRB at Teachers College, Columbia University, 525 W. 120th Street, New York, NY 1002. The IRB is the committee that oversees human research protection for Teachers College, Columbia University.

PARTICIPANT'S RIGHTS

- I have read the informed consent and have had the opportunity to contact the investigator with any questions about the purposes, procedures, risks and benefits regarding this research study.
- I understand that my participation is voluntary. I may refuse to participate or withdraw participation at any time without penalty.
- If, during the course of the study, significant new information that has been developed becomes available which may relate to my willingness to continue my participation, the investigator will provide this information to me.
- Any information derived from the research study that personally identifies me will not be voluntarily released or disclosed without my separate consent, except as specifically required by law.
- I should receive a copy of the Informed Consent document.

Checking off on this box means that I agree to participate in this study

Teachers College, Columbia University
525 West 120th Street
New York NY 10027
212 678 3000

INFORMED CONSENT

Protocol Title: Exploration of In-Service Teacher Views on Multiculturalism in Science

Classrooms: Interview Consent

Principal Investigator: Samir Biswas, Teachers College 917-992-5049

INTRODUCTION
You are being invited to participate in this research study called "Exploration of In-Service Teacher Views on Multiculturalism in Science Classrooms." You may qualify to take part in this research study because you are a practicing science educator and are over 18 years old**.** Approximately 20 people will participate in this phase of the study and it will take one hour of your time to complete.

WHY IS THIS STUDY BEING DONE?
Work in the field of science education has illustrated that differences between student home culture and the culture of the classroom has impacts on their engagement and achievement in science. This study is being done to determine the views of in-service educators towards multiculturalism in the classroom setting, and the practices of in-service teachers that may impact students from diverse cultural backgrounds. The study will examine if there are existing differences based on educator's subject of specializations (biology, chemistry, Earth science, physics, etc.) in regards to these views and practices.

WHAT WILL I BE ASKED TO DO IF I AGREE TO TAKE PART IN THIS STUDY?
If you decide to participate, you will complete a series of interview questions on your views and practices**.**
It is recognized that cultural diversity, multiculturalism, and the related issues of race, ethnicity, social status, and access to resources may present topics of sensitivity. As such participants will be given the opportunity to omit or bypass questions that they are uncomfortable answering, or if necessary terminate surveys should participants deem it necessary to do so.

WHAT POSSIBLE RISKS OR DISCOMFORTS CAN I EXPECT FROM TAKING PART IN THIS STUDY?

This is a minimal risk study, which means the harms or discomforts that you may experience are not greater than you would ordinarily encounter in daily life while taking routine physical or psychological examinations or tests. Although there are no physical risks for participants in this study, it is recognized that the discussion of cultural diversity, multiculturalism, and the related issues of race, ethnicity, social status, and access to resources may present topics of sensitivity. You will have the opportunity to omit or bypass questions that you are uncomfortable answering, or if necessary terminate any interviews or surveys should they deem it necessary to do so. You can stop participating in the study at any time without penalty. You might feel concerned that things you say might get back to your principal.

The principal investigator is taking precautions to keep your information confidential and prevent anyone from discovering or guessing your identity. All participant data will be collected using a Pseudonym for reference in the study and any subsequent publications. Data from the interview will be kept on a password protected computer and locked in a file drawer.

WHAT POSSIBLE BENEFITS CAN I EXPECT FROM TAKING PART IN THIS STUDY?

There is no direct benefit to you for participating in this study. Participation may benefit the field of teacher education to better understand the best way to prepare science educators.

WILL I BE PAID FOR BEING IN THIS STUDY?

You will not be paid to participate and there are no costs to you for taking part in this study.

WHEN IS THE STUDY OVER? CAN I LEAVE THE STUDY BEFORE IT ENDS?

The study is over when you have completed the interview. However, you can leave the study at any time even if you haven't finished the interview protocol.

PROTECTION OF YOUR CONFIDENTIALITY

The investigator will keep all written materials locked in a desk drawer in a locked office. Any electronic or digital information will be stored on a computer that is password protected. Regulations require that research data be kept for at least three years.

What is on the audio-recording will be written down and the audio-recording will then be destroyed. There will be no record matching your real name with your pseudonym.

HOW WILL THE RESULTS BE USED?

The results of this study will be published in journals and presented at academic conferences. Your name or any identifying information about you will not be published. This study is being conducted as part of the dissertation of the principal investigator.

CONSENT FOR AUDIO RECORDING

Audio recording is part of this research study. You can choose whether to give permission to be recorded. If you decide that you don't wish to be recorded, you will not be able to participate in this research study.

______I give my consent to be recorded ____

Signature

______I **do not** consent to be recorded ____

Signature

<u>WHO MAY VIEW MY PARTICIPATION IN THIS STUDY</u>

___I consent to allow written transcripts of audio taped materials viewed at an educational setting or at a conference outside of Teachers College ____________________________
Signature

___I **do not** consent to allow written transcripts of audio taped materials viewed outside of Teachers College Columbia University ____
Signature

<u>OPTIONAL CONSENT FOR FUTURE CONTACT</u>

The investigator may wish to contact you in the future. Please initial the appropriate statements to indicate whether or not you give permission for future contact.

I give permission to be contacted in the future for research purposes:

Yes ___________________________ No__________________________
Initial Initial

I give permission to be contacted in the future for information relating to this study:

Yes ___________________________ No__________________________
Initial Initial

<u>WHO CAN ANSWER MY QUESTIONS ABOUT THIS STUDY?</u>

If you have any questions about taking part in this research study, you should contact the principal investigator, Samir Biswas, at 917-992-5049 or at scb2163@tc.columbia.edu **You can also contact the faculty advisor, Dr. Felicia Mensah at fm2140@tc.columbia.edu.)**

If you have questions or concerns about your rights as a research subject, you should contact the Institutional Review Board (IRB) (the human research ethics committee) at 212-678-4105 or email IRB@tc.edu. Or you can write to the IRB at Teachers College, Columbia University, 525 W. 120th Street, New York, NY 1002. The IRB is the committee that oversees human research protection for Teachers College, Columbia University.

PARTICIPANT'S RIGHTS

- I have read and discussed the informed consent with the researcher. I have had ample opportunity to ask questions about the purposes, procedures, risks and benefits regarding this research study.
- I understand that my participation is voluntary. I may refuse to participate or withdraw participation at any time without penalty to future
- If, during the course of the study, significant new information that has been developed becomes available which may relate to my willingness to continue my participation, the investigator will provide this information to me.
- Any information derived from the research study that personally identifies me will not be voluntarily released or disclosed without my separate consent, except as specifically required by law.
- I should receive a copy of the Informed Consent document.

My signature means that I agree to participate in this study

Print name: ____ **Date**: _______________________

Signature: ____

Appendix C

Survey Instrument

SURVEY ON MULTICULTURALISM IN THE SCIENCE CLASSROOM

The items below were presented to participants through the Qualtrics online data collection suite.

Background and Demographic Data (participants can select responses from drop down menus, answer choices are indicated in the brackets following the question)

1. I have read, understood, and printed a copy of, the above consent form and desire of my own free will to participate in this study. [Yes/No]
2. In what state do you currently teach? [Drop down menu listing all US states and territories)]
3. How long have you been a teacher / educator? [1-3 years, 4-10 years, 11-20 years, 21-30 years, 30+ years]
4. What is your gender? [male / female / other]
5. What is your age? [20-29 years, 30-39 years,40-49 years, 50-59 years, 60-69 years, 70+ years]
6. What is your race? [White/Caucasian/European descent, African-American (non-Latino), Latino/Latina,
7. Which of the following best describes the school setting you teach in? [Rural, Urban, Suburban]
8. What grade(s) do you teach? [8,9,10,11,12]
9. What is your primary area of certification? [Biology, Chemistry, Earth science, Physics, General Science, Other – specify]
10. What subject(s) do you teach?
11. Do any of the classes you teach have the following designations? [Honors ,Gifted, IB,AP / ELL, Bilingual / Special Education, Inclusion]
12. Do you hold any roles beyond that of direct instruction of students? [yes/no]
13. If so how would you describe your additional responsibilities?

Teacher Preparation (Likert questions unless otherwise indicated)

14. Have you taken, or are you now taking, coursework focused on diversity or multiculturalism in the school setting? *(Yes/No with contingency for next question)*

15. If so, was the coursework required as part of your educational or certification programs.

16. Have you taken, or are you now taking, professional development through your district (or school) focused on diversity or multiculturalism in the school setting? *(Yes/No with contingency for next question)*

17. If so, was the PD a district (or school) requirement? *(Yes/No) with contingency for next question*

18. I feel adequately prepared to teach students of diverse cultural backgrounds *(Likert)*

Defining Cultural Diversity *(Questions are free response)*

19. This study asks many questions focused around the themes of multiculturalism and cultural diversity in the classroom. How do you define "cultural diversity"? *(Free Response)*

20. How would you describe the mainstream (dominant) culture of America? *(Free Response)*

Personal Views on Diversity (Likert questions unless otherwise indicated)

21. It is important to celebrate cultural diversity.

22. Everyone should be knowledgeable about the cultural practices of people of other cultural backgrounds.

23. There are just as many differences within cultures as there are between cultures.

24. A person's cultural identity is as important as their individual identity.

25. It is important to recognize the contributions of different cultures to the culture of America.

26. Different cultural groups have different cultural needs.

27. People should develop meaningful friendships with others from different racial/ethnic groups. (from Pohan and Aguillar, 2001)

28. Do you have any comments or questions to expand upon the statements in the section above? If so, please include them in the space below. *(Free Response)*

Cultural Norms (Likert questions unless otherwise indicated)

29. Cultural norms in America predominantly support White/ Eurocentric perspectives.

30. Cultural norms in America may advantage certain populations over others.

31. It is difficult for people of multicultural backgrounds to become successful in America.

32. To become successful in America, people from diverse cultural backgrounds should adopt mainstream cultural practices.

33. It is important for people of White background to be knowledgeable about the cultural backgrounds of people from diverse cultural backgrounds.

34. Do you have any comments or questions to expand upon the statements in the section above? If so, please include them in the space below. *(Free Response)*

Views on Multiculturalism in Practice (Likert questions unless otherwise indicated)

35. Teachers benefit from having a basic understanding of diverse cultures. (adapted from Pohan and Aguillar, 2001)

36. Students benefit from having a basic understanding of diverse cultures. (adapted from Pohan and Aguillar, 2001)

37. All students should be encouraged to learn about the practices of other cultures.

38. Only schools serving multicultural students need a racially, ethnically, and culturally diverse staff and faculty. (from Pohan and Aguillar, 2001)

39. Multicultural education is most beneficial for students of multicultural backgrounds. (adapted from Pohan and Aguillar, 2001)

40. Multicultural education is less important than reading, writing, arithmetic, and computer literacy. (adapted from Pohan and Aguillar, 2001)

41. Do you have any comments or questions to expand upon the statements in the section above? If so, please include them in the space below. *(Free Response)*

Multicultural Background, Curriculum, and Student Performance (Likert questions unless otherwise indicated)

42. The cultural background of a student should not impact performance in science because science is an inherently objective discipline.
43. Students from different cultural backgrounds learn better from different methods of instruction.
44. A student's cultural background can correlate to how they perform in a science class.
45. In general, White people place a higher value on education than do people from other cultural backgrounds. (from Pohan and Aguillar, 2001)
46. Science curriculum generally reflects a modern Western / Eurocentric perspective.
47. White students are given more opportunities in math and science than students from other cultural backgrounds.
48. People of color or with multicultural backgrounds are adequately represented in most textbooks and curricular material.
49. Science curriculum reflects the contribution of many global cultures.
50. Science classes should acknowledge the specific contributions of other cultures to the disciplines of science.
51. Do you have any comments or questions to expand upon the statements in the section above? If so, please include them in the space below. *(Free Response)*

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52. How would you describe the cultural backgrounds of the school(s) in which you teach? *(Free response)*
53. The cultural backgrounds of the classes I teach reflect the cultural makeup of my school as a whole. (Likert)
54. Please feel free to elaborate on the statement above. *(Free response)*

Multicultural Backgrounds and Instruction (Likert questions unless otherwise indicated)

55. It is important that content be framed in context of students' cultural understandings.
56. The attention given to multicultural backgrounds is comparable to that given to the needs of students of traditionally White background. (adapted from Pohan and Aguillar, 2001)
57. The cultural background of a teacher can impact the educational experience of students.
58. Only schools serving multicultural students need a racially, ethnically, and culturally diverse staff and faculty. (from Pohan and Aguillar, 2001)
59. To be effective with all students, teachers should have experience working with students from diverse racial and ethnic backgrounds. (adapted from Pohan and Aguillar, 2001)
60. Do you have any comments or questions to expand upon the statements in the section above? If so, please include them in the space below. *(Free Response)*

Multicultural Backgrounds and Instruction (Likert questions unless otherwise indicated)

61. Having cultural diversity in my class benefits everyone in the class.
62. It is important to identify the cultural backgrounds of the students in my classes.
63. I make changes to my instruction to address cultural differences in my classes.
64. I include content for the entire class related to culturally diverse backgrounds
65. Providing opportunities for students of diverse cultural backgrounds to share their views or opinions enriches the experience for all students.
66. Science instruction should have a focus on understanding the inequities and cultural differences that may exist between groups.
67. Science instruction should have a focus on taking social action to address inequities and cultural differences that exist between groups
68. Are the any strategies that you have used in order to address cultural differences in your classes? *{Yes/No, with contingency for following question}*
69. Please elaborate on any strategies you incorporate into your classes. *(Free Response)*

70. Do you have any comments or questions to expand upon the statements in the section above? If so, please include them in the space below. *(Free Response)*

Difficulties with Multicultural Backgrounds and Instruction (Likert questions unless otherwise indicated)

71. Having cultural diversity in a class makes it more difficult to teach the content.
72. Providing opportunities for students of diverse cultural backgrounds to share their views or opinions takes away from the time necessary to address science content.
73. Students of diverse cultural backgrounds often have greater difficulty with understanding content from the course.
74. Please elaborate on specific difficulties you find when instructing students of diverse cultural backgrounds. *(Free Response)*
75. Do you have any comments or questions to expand upon the statements in the section above? If so, please include them in the space below. *(Free Response)*

Multicultural Backgrounds and Instruction (Likert questions unless otherwise indicated)

76. Regardless of cultural differences, all students should be taught the same way.
77. All students, regardless of cultural background, should be held to the same academic expectations
78. It is the student's responsibility to make accommodations to overcome cultural barriers to understanding content.
79. It is the teacher's responsibility to make accommodations to overcome cultural barriers to understanding content.
80. Do you have any comments or questions to expand upon the statements in the section above? If so, please include them in the space below. *(Free Response)*

Multicultural Backgrounds and Professional Responsibilities (Likert questions unless otherwise indicated)

81. I would prefer to work with students and parents whose cultures are more similar to mine.

82. I am less likely to contact a student's home if I feel there may be cultural barriers between me and their parents.

83. I meet with other teachers to discuss how to approach student homes if there are cultural barriers between me and their parents.

84. Do you have any comments or questions to expand upon the statements in the section above? If so, please include them in the space below. *(Free Response)*

Thank you and Conclusion

85. I feel adequately prepared to teach students of diverse cultural backgrounds. (Likert Scale)

86. Thank you for your participation in this survey. Do you have any comments or questions regarding multiculturalism in the classroom that you would like to share? *(Free Response)*

Contact for Further Study

87. Would you be interested in participating in a follow-up interview to further discuss results? The interview may take 45 minutes to an hour and can be scheduled to accommodate your needs. If interested, please follow the link below. Contact information will be kept separate of the data collected in this survey to ensure the anonymity of the participants of the survey you have completed.

Appendix D

Interview Protocol

1. Tell me about your background as a teacher
    a. How many years of experience do you have as a teacher?
    b. What subject areas are you certified to teach?
    c. What subjects are you currently teaching?
    d. What other subjects have you taught in the past?
    e. Do you perform any additional roles in your building beyond direct instruction of student? If so please describe them.
2. What does the term cultural diversity mean to you?
3. What does the term multiculturalism mean to you?
4. How would you describe yourself in terms of race and ethnicity?
5. Do you see any impacts of your race or ethnicity in terms of your dealings with your students?
6. How would you describe the importance of having understandings on multiculturalism?
    a. Do you think it is of benefit for students to learn in a multicultural setting?
    b. If any, what do you see as the positives for students?
    c. If any, what do you see as the negatives for students?
7. Please describe the extent to which you would consider there to be cultural diversity among the students you currently teach.
8. How does that compare to the cultural diversity of your school as a whole?
9. Do you take cultural diversity into account as part of your instruction?
    a. What, if any, elements of multiculturalism do you find embedded in science instruction?
    b. Should cultural diversity of your class impact your instruction of science?
    c. How does cultural diversity impact your lesson planning?
    d. How does cultural diversity impact the implementation of your lesson planning?

e. How does cultural diversity impact the classroom environment?

f. Are there any benefits that the cultural diversity in your classroom affords you?

g. Are there any challenges that you find from the cultural diversity in your classroom?

10. Do you see the cultural diversity of the student body impacting different science courses in different ways?

11. Are there distinctions you would make in how cultural diversity may affect other subjects outside of science?

12. How do you think students' cultural backgrounds impact their performance in your class?

13. Are there particular challenges you face when communicating with students with cultural backgrounds different from your own?

14. Are there other challenges that you feel you face beyond communication when interacting with students of cultural backgrounds different from your own?

15. Are there particular strategies you utilize when working with students with cultural backgrounds different from your own?

16. Do you find yourself differentiating your instruction for students of cultural backgrounds different from your own? Please elaborate.

17. Do you find yourself differentiating your expectation for students of cultural backgrounds different from your own?

18. Do cultural differences ever impact the communication you have with parents or families of the students in your class? Please elaborate.

19. Based on our conversation, are there any additional thoughts on multiculturalism or cultural diversity that you would like to share?

Appendix E

Likert Item Responses of All Teachers for Survey on Multiculturalism in the Science Classroom

Table E-1

Summary of All Teacher Responses to Likert Items for Factor 1: Teachers' Beliefs and Attitudes on Multiculturalism (n= 152)

	Percentages		
Abbreviated Items	Agree	Neutral	Disagree
1. It is important to celebrate cultural diversity.	92.1	2.6	5.3
2. Everyone should be knowledgeable about the cultural practices of others.	94.0	2.6	3.3
3. It is important to recognize the contributions different cultures Have made to the culture of America.	96.0	0.7	3.3
4. Having cultural diversity in my class benefits everyone.	91.0	6.2	2.8
5. All students should be encouraged to learn about the practices of other cultures.	95.3	2.7	2.0
6. Students benefit from a basic understanding of diverse cultures.	98.7	1.3	0.0
7. People should develop meaningful friendships with people of different racial/ethnic groups.	91.3	8.7	0.0
8. White people should learn about diverse cultural backgrounds.	94.0	3.4	2.7

(continued)

Table E-1

Summary of All Teacher Responses to Likert Items for Factor 1: Teachers' Beliefs and Attitudes on Multiculturalism (n= 152) continued

	Percentages		
Abbreviated Items	Agree	Neutral	Disagree
9. Opportunities for students of multicultural backgrounds enrich the experience for all students.	93.8	4.8	1.4
10. A person's cultural identity is as important as their individual identity.	82.8	9.3	7.9
11. It is important to identify the cultural backgrounds of my students.	73.3	11.0	15.8
12. Teachers benefit from having a basic understanding of diverse cultures.	98.7	1.3	0.0
13. It is important that content be framed in the context of students' cultural understandings.	70.5	15.8	13.7
14. The science classroom is an appropriate space to include multicultural perspectives.	80.4	10.1	9.5
15. Teachers should have experience working with students of diverse backgrounds.	80.8	8.2	11.0
16. There are just as many differences within cultures as there are between cultures.	92.1	4.6	3.3
17. Different cultural groups have different needs.	89.5	2.6	7.9
18. The cultural background of a teacher has an impact on students.	87.7	8.2	4.1

Note. Abbreviated versions of survey items are used for conciseness. See Appendix C for complete versions of the items.

Table E-2

Summary of All Teacher Responses to Likert Items for Factor 2: Cultural Norms in Curriculum and Instruction (N= 152)

	Percentages		
Abbreviated Items	Agree	Neutral	Disagree
19. Science curriculum reflects the contributions of many cultures.	39.5	14.3	46.3
20. Regardless of cultural differences, all students should be taught the same way.	15.9	11.0	73.1
21. Multicultural backgrounds are adequately represented in most curricular materials.	45.7	14.3	70.1
22. Cultural norms in America advantage certain populations.	97.3	2.7	0.0
23. Science curriculum generally reflects a modern Western / Eurocentric perspective.	81.6	11.6	6.8
24. It is difficult for people of multicultural backgrounds to become successful in America.	45.6	13.4	40.9
25. Only schools serving multicultural students need diverse staff.	7.5	5.5	87.0
26. It is the student's responsibility to make accommodations to overcome cultural barriers.	26.7	9.6	63.7
27. Cultural background should not impact performance because science is objective.	52.4	5.4	42.2
28. White students have more opportunities in mathematics and science than others.	41.8	13.0	45.2
29. Needs of multicultural students receive equal attention when compared to their White classmates (38).	66.9	15.2	17.9

Note. Abbreviated versions of survey items are used for conciseness. See Appendix C for complete versions of the items.

Table E-3

Summary of All Teacher Responses to Likert Items for Factor 3: Challenges and Concerns Related to Working with Students of Multicultural Backgrounds (N= 152)

Abbreviated Items	Percentages		
	Agree	Neutral	Disagree
30. Students of multicultural backgrounds often have greater difficulty with understanding science content.	15.1	14.4	70.5
31. Cultural diversity in a class makes it more difficult to teach science content.	14.5	13.8	71.7
32. Multicultural students are more likely to require remedial courses.	26.9	22.8	50.3
33. Sharing cultural perspectives takes away from time for content.	14.4	11.6	74.0
34. Culturally diverse students are less academically prepared for achievement in science.	33.8	16.6	49.7
35. I am less likely to contact a student's home if there are cultural barriers between me and their parents.	20.7	13.1	66.2
36. I would prefer to work with students with backgrounds similar to mine.	8.2	25.3	66.4
37. White people place a higher value on education than other cultures.	6.2	11.0	82.9
38. Multicultural students are as likely to succeed in upper level and honors classes.	59.0	16.0	25.0
39. To become successful in America, people from multicultural backgrounds should adopt mainstream cultural practices.	36.9	22.1	40.9

(continued)

Table E-3

Summary of All Teacher Responses to Likert Items for Factor 3 Challenges and Concerns Related to Working with Students of Multicultural Backgrounds (N= 152) continued

	Percentages		
Abbreviated Items	Agree	Neutral	Disagree
40. Multicultural education is less important than reading, writing, arithmetic, and computer literacy.	31.8	20.3	48.0
41. All students, regardless of cultural background, should be held to the same academic expectations.	86.3	4.1	9.6

Note. Abbreviated versions of survey items are used for conciseness. See Appendix C for complete versions of the items.

Table E-4

Summary of All Teacher Responses to Likert Items for Factor 4: Instructional Practices (N= 152)

Abbreviated Items	Percentages		
	Agree	Neutral	Disagree
42. Students from different cultural backgrounds learn better from different methods of instruction.	57.1	26.5	16.3
43. I make changes to my instruction to address cultural differences.	68.5	14.4	17.1
44. Science instruction should have a focus on understanding inequities and cultural differences.	48.3	20.0	31.7
45. I include content related to the backgrounds of multicultural students.	65.1	16.4	18.5
46. Science instruction should have a focus on taking social action to address inequities and cultural differences.	47.3	18.5	34.2
47. It is the teacher's responsibility to address cultural barriers to understanding content.	91.8	3.4	4.8
48. A student's cultural background correlates to performance in science.	50.3	20.4	29.3
49. Multicultural education is most beneficial for students of multicultural backgrounds.	16.9	14.2	68.9

Note. Abbreviated versions of survey items are used for conciseness. See Appendix C for complete versions of the items.

Table E-5

Summary of All Teacher Responses to Likert Items for Factor 5: Teacher Preparation (N= 152)

	Percentages		
Abbreviated Items	Agree	Neutral	Disagree
50. I feel adequately prepared to teach students of diverse cultural backgrounds.	82.9	6.7	10.4
51. Upon reflection of my responses to the survey, I feel adequately prepared to teach students of diverse cultural backgrounds.	80.8	4.8	14.4
52. I meet with other teachers or staff to address contacting homes if there are cultural barriers between me and their parents.	69.9	14.4	15.8
53. Only schools serving multicultural students need a racially, ethnically, and culturally diverse faculty.	7.4	4.7	87.9

Note. Abbreviated versions of survey items are used for conciseness. See Appendix C for complete versions of the items.

Appendix F

Likert Item Responses of Biology Teachers on Survey on Multiculturalism in the Science Classroom

Table F-1

Summary of Biology Teacher Responses to Likert Items for Factor 1: Teachers' Beliefs and Attitudes on Multiculturalism (n= 67)

	Percentages		
Abbreviated Items	Agree	Neutral	Disagree
1. It is important to celebrate cultural diversity.	93.9	4.5	1.5
2. Everyone should be knowledgeable about the cultural practices of others.	93.9	4.5	1.5
3. It is important to recognize the contributions different cultures Have made to the culture of America.	97.0	1.5	1.5
4. Having cultural diversity in my class benefits everyone.	93.8	4.7	1.6
5. All students should be encouraged to learn about the practices of other cultures.	98.5	1.5	0.0
6. Students benefit from a basic understanding of diverse cultures.	100	0.0	0.0
7. People should develop meaningful friendships with people of different racial/ethnic groups.	92.4	7.6	0.0
8. White people should learn about diverse cultural backgrounds.	95.5	4.5	0.0
9. Opportunities for students of multicultural backgrounds enrich the experience for all students.	95.3	4.7	0.0

(continued)

Table F-1

Summary of Biology Teacher Responses to Likert Items for Factor 1: Teachers' Beliefs and Attitudes on Multiculturalism (n= 67) continued

Abbreviated Items	Percentages		
	Agree	Neutral	Disagree
10. A person's cultural identity is as important as their individual identity.	81.8	1.6	7.6
11. It is important to identify the cultural backgrounds of my students.	78.1	6.3	15.6
12. Teachers benefit from having a basic understanding of diverse cultures.	98.5	1.5	0.0
13. It is important that content be framed in the context of students' cultural understandings.	78.1	10.9	10.9
14. The science classroom is an appropriate space to include multicultural perspectives.	89.2	6.2	4.6
15. Teachers should have experience working with students of diverse backgrounds.	81.3	9.4	3.1
16. There are just as many differences within cultures as there are between cultures.	90.9	7.6	1.5
17. Different cultural groups have different needs.	90.0	4.5	4.5
18. The cultural background of a teacher has an impact on students.	87.5	9.4	3.1

Note. Abbreviated versions of survey items are used for conciseness. See Appendix C for complete versions of the items.

Table F-2

Summary of Biology Teacher Responses to Likert Items for Factor 2: Cultural Norms in Curriculum and Instruction (N= 67)

	Percentages		
Abbreviated Items	Agree	Neutral	Disagree
19. Science curriculum reflects the contributions of many cultures.	45.3	9.4	45.3
20. Regardless of cultural differences, all students should be taught the same way.	20.6	11.1	68.3
21. Multicultural backgrounds are adequately represented in most curricular materials.	12.5	17.2	70.3
22. Cultural norms in America advantage certain populations.	97.0	3.0	3.0
23. Science curriculum generally reflects a modern Western / Eurocentric perspective.	76.6	12.5	10.9
24. It is difficult for people of multicultural backgrounds to become successful in America.	42.4	9.1	48.5
25. Only schools serving multicultural students need diverse staff.	6.3	7.8	85.9
26. It is the student's responsibility to make accommodations to overcome cultural barriers.	26.6	9.4	64.1
27. Cultural background should not impact performance because science is objective.	46.9	6.3	46.9
28. White students have more opportunities in mathematics and science than others.	39.1	10.9	50.0
29. Needs of multicultural students receive equal attention when compared to their White classmates.	64.1	14.1	21.9

Note. Abbreviated versions of survey items are used for conciseness. See Appendix C for complete versions of the items.

Table F-3

Summary of Biology Teacher Responses to Likert Items for Factor 3: Challenges and Concerns Related to Working with Students of Multicultural Backgrounds (N= 67)

	Percentages		
Abbreviated Items	Agree	Neutral	Disagree
30. Students of multicultural backgrounds often have greater difficulty with understanding science content.	9.4	12.5	78.1
31. Cultural diversity in a class makes it more difficult to teach science content.	11.1	11.1	77.8
32. Multicultural students are more likely to require remedial courses.	23.8	2.6	55.6
33. Sharing cultural perspectives takes away from time for content.	14.1	9.4	76.6
34. Culturally diverse students are less academically prepared for achievement in science.	25.4	19.0	55.6
35. I am less likely to contact a student's home if there are cultural barriers between me and their parents.	20.3	10.9	68.8
36. I would prefer to work with students similar to mine.	12.5	21.9	65.6
37. White people place a higher value on education than other cultures.	4.7	10.9	84.4
38. Multicultural students are as likely to succeed in upper level and honors classes.	66.7	12.7	20.6
39. To become successful in America, people from multicultural backgrounds should adopt mainstream cultural practices.	34.8	18.2	47.0

(continued)

Table F-3

Summary of Biology Teacher Responses to Likert Items for Factor 3: Challenges and Concerns Related to Working with Students of Multicultural Backgrounds (N= 67) continued

Abbreviated Items	Percentages		
	Agree	Neutral	Disagree
40. Multicultural education is less important than reading, writing, arithmetic, and computer literacy.	35.4	16.9	47.7
41. All students, regardless of cultural background, should be held to the same academic expectations.	84.4	4.7	10.9

Note. Abbreviated versions of survey items are used for conciseness. See Appendix C for complete versions of the items.

Table F-4

Summary of Biology Teacher Responses to Likert Items for Factor 4: Instructional Practices (N= 67)

	Percentages		
Abbreviated Items	Agree	Neutral	Disagree
42. Students from different cultural backgrounds learn better from different methods of instruction.	57.8	28.1	14.1
43. I make changes to my instruction to address cultural differences.	76.0	14.1	9.9
44. Science instruction should have a focus on understanding inequities and cultural differences.	52.4	17.5	30.2
45. I include content related to the backgrounds of multicultural students.	71.9	15.6	12.5
46. Science instruction should have a focus on taking social action to address inequities and cultural differences.	42.2	23.4	34.4
47. It is the teacher's responsibility to address cultural barriers to understanding content.	93.8	3.1	3.1
48. A student's cultural background correlates to performance in science.	46.9	20.3	32.8
49. Multicultural education is most beneficial for students of multicultural backgrounds.	18.5	16.9	64.6

Note. Abbreviated versions of survey items are used for conciseness. See Appendix C for complete versions of the items.

Table F-5

Summary of Biology Teacher Responses to Likert Items for Factor 5: Teacher Preparation (N= 67)

	Percentages		
Abbreviated Items	Agree	Neutral	Disagree
50. I feel adequately prepared to teach students of diverse cultural backgrounds.	83.5	7.7	8.8
51. Upon reflection of my responses to the survey, I feel adequately prepared to teach students of diverse cultural backgrounds.	85.9	1.6	12.5
52. I meet with other teachers or staff to address contacting homes if there are cultural barriers between me and their parents.	65.6	14.1	20.3
53. Only schools serving multicultural students need a racially, ethnically, and culturally diverse faculty.	6.1	7.6	86.4

Note. Abbreviated versions of survey items are used for conciseness. See Appendix C for complete versions of the items.

Appendix G

Likert Item Responses of Chemistry Teachers on Survey on Multiculturalism in the Science Classroom

Table G-1

Summary of Chemistry Teacher Responses to Likert Items for Factor 1: Teachers' Beliefs and Attitudes on Multiculturalism (n= 44)

	Percentages		
Abbreviated Items	Agree	Neutral	Disagree
1. It is important to celebrate cultural diversity.	93.2	0.0	6.8
2. Everyone should be knowledgeable about the cultural practices of others.	95.5	0.0	4.5
3. It is important to recognize the contributions different cultures Have made to the culture of America.	95.3	0.0	4.7
4. Having cultural diversity in my class benefits everyone.	88.4	7.0	4.7
5. All students should be encouraged to learn about the practices of other cultures.	93.2	4.5	2.3
6. Students benefit from an understanding of diverse cultures.	95.5	4.5	0.0
7. People should develop meaningful friendships with people of different racial/ethnic groups.	90.9	9.1	0.0
8. White people should learn about diverse cultural backgrounds.	93.2	0.0	6.8

(continued)

Table G-1

Summary of Chemistry Teacher Responses to Likert Items for Factor 1: Teachers' Beliefs and Attitudes on Multiculturalism (n= 44) continued

	Percentages		
Abbreviated Items	Agree	Neutral	Disagree
9. Opportunities for students of multicultural backgrounds enrich the experience for all students.	88.6	9.1	2.3
10. A person's cultural identity is as important as their individual identity.	84.1	9.1	6.8
11. It is important to identify the cultural backgrounds of my students.	64.7	23.5	11.8
12. Teachers benefit from having a basic understanding of diverse cultures.	97.7	2.3	0.0
13. It is important that content be framed in the context of students' cultural understandings.	54.5	36.4	9.1
14. The science classroom is an appropriate space to include multicultural perspectives.	70.5	13.6	15.9
15. Teachers should have experience working with students of diverse backgrounds.	77.3	6.8	15.9
16. There are just as many differences within cultures as there are between cultures.	88.6	4.5	6.8
17. Different cultural groups have different needs.	88.6	9.1	6.8
18. The cultural background of a teacher has an impact on students.	84.1	9.1	6.8

Note. Abbreviated versions of survey items are used for conciseness. See Appendix C for complete versions of the items.

Table G-2

Summary of Chemistry Teacher Responses to Likert Items for Factor 2: Cultural Norms in Curriculum and Instruction (N= 44)

	Percentages		
Abbreviated Items	Agree	Neutral	Disagree
19. Science curriculum reflects the contributions of many cultures.	29.5	20.5	50.0
20. Regardless of cultural differences, all students should be taught the same way.	11.4	11.4	77.3
21. Multicultural backgrounds are adequately represented in most curricular materials.	18.2	9.1	72.7
22. Cultural norms in America advantage certain populations.	95.5	4.5	0.0
23. Science curriculum generally reflects a modern Western / Eurocentric perspective.	86.4	9.1	4.5
24. It is difficult for people of multicultural backgrounds to become successful in America.	40.9	20.5	38.6
25. Only schools serving multicultural students need diverse staff.	13.6	2.3	84.1
26. It is the student's responsibility to make accommodations to overcome cultural barriers.	20.5	13.6	65.9
27. Cultural background should not impact performance because science is objective.	56..8	4.5	38.6
28. White students have more opportunities in mathematics and science than others.	41.9	18.6	39.5
29. Needs of multicultural students receive equal attention when compared to their White classmates.	74.4	16.3	9.3

Note. Abbreviated versions of survey items are used for conciseness. See Appendix C for complete versions of the items.

Table G-3

Summary of Chemistry Teacher Responses to Likert Items for Factor 3: Challenges and Concerns Related to Working with Students of Multicultural Backgrounds (N= 44)

	Percentages		
Abbreviated Items	Agree	Neutral	Disagree
30. Students of multicultural backgrounds often have greater difficulty with understanding science content.	20.5	15.9	63.6
31. Cultural diversity in a class makes it more difficult to teach science content.	13.6	20.5	65.9
32. Multicultural students are more likely to require remedial courses.	27.3	25.0	47.7
33. Sharing cultural perspectives takes away from time for content.	18.2	13.6	68.2
34. Culturally diverse students are less academically prepared for achievement in science.	38.6	18.2	43.2
35. I am less likely to contact a student's home if there are cultural barriers between me and their parents.	25.0	18.2	56.8
36. I would prefer to work with students similar to mine.	0.0	43.2	56.8
37. White people place a higher value on education than other cultures.	7.0	7.0	86.0
38. Multicultural students are as likely to succeed in upper level and honors classes.	47.1	11.8	42.2
39. To become successful in America, people from multicultural backgrounds should adopt mainstream cultural practices.	43.2	29.5	27.3

(continued)

Table G-3

Summary of Chemistry Teacher Responses to Likert Items for Factor 3: Challenges and Concerns Related to Working with Students of Multicultural Backgrounds (N= 44) continued

	Percentages		
Abbreviated Items	Agree	Neutral	Disagree
40. Multicultural education is less important than reading, writing, arithmetic, and computer literacy.	27.3	34.1	38.6
41. All students, regardless of cultural background, should be held to the same academic expectations.	88.6	6.8	4.5

Note. Abbreviated versions of survey items are used for conciseness. See Appendix C for complete versions of the items.

Table G-4

Summary of Chemistry Teacher Responses to Likert Items for Factor 4: Instructional Practices (N= 44)

	Percentages		
Abbreviated Items	Agree	Neutral	Disagree
42. Students from different cultural backgrounds learn better from different methods of instruction.	52.3	27.3	20.5
43. I make changes to my instruction to address cultural differences.	65.9	13.6	20.5
44. Science instruction should have a focus on understanding inequities and cultural differences.	47.7	20.5	31.8
45. I include content related to the backgrounds of multicultural students.	56.8	15.9	27.3
46. Science instruction should have a focus on taking social action to address inequities and cultural differences.	45.5	27.3	27.3
47. It is the teacher's responsibility to address cultural barriers to understanding content.	90.9	4.5	4.5
48. A student's cultural background correlates to performance in science.	45.5	27.3	27.3
49. Multicultural education is most beneficial for students of multicultural backgrounds.	20.5	13.6	65.9

Note. Abbreviated versions of survey items are used for conciseness. See Appendix C for complete versions of the items.

Table G-5

Summary of Chemistry Teacher Responses to Likert Items for Factor 5: Teacher Preparation (N= 44)

	Percentages		
Abbreviated Items	Agree	Neutral	Disagree
50. I feel adequately prepared to teach students of diverse cultural backgrounds.	81.8	7.3	10.9
51. Upon reflection of my responses to the survey, I feel adequately prepared to teach students of diverse cultural backgrounds.	68.2	13.6	18.2
52. I meet with other teachers or staff to address contacting homes if there are cultural barriers between me and their parents.	65.9	18.2	15.9
53. Only schools serving multicultural students need a racially, ethnically, and culturally diverse faculty.	13.6	4.5	81.8

Note. Abbreviated versions of survey items are used for conciseness. See Appendix C for complete versions of the items.

Appendix H

Likert Item Responses of Physics Teachers on Survey on Multiculturalism in the Science Classroom

Table H-1

Summary of Physics Teacher Responses to Likert Items for Factor 1: Beliefs and Attitudes on Multiculturalism (n= 22)

	Percentages		
Abbreviated Items	Agree	Neutral	Disagree
1. It is important to celebrate cultural diversity.	90.9	0.0	9.1
2. Everyone should be knowledgeable about the cultural practices of others.	95.5	0.0	4.5
3. It is important to recognize the contributions different cultures Have made to the culture of America.	95.5	0.0	4.5
4. Having cultural diversity in my class benefits everyone.	85.7	14.3	0.0
5. All students should be encouraged to learn about the practices of other cultures.	95.2	0.0	4.8
6. Students benefit from an understanding of diverse cultures.	100	0.0	0.0
7. People should develop meaningful friendships with people of different racial/ethnic groups.	90.5	9.5	0.0
8. White people should learn about diverse cultural backgrounds.	90.5	4.8	4.8
9. Opportunities for students of multicultural backgrounds enrich the experience for all students.	95.2	0.0	4.8

(continued)

Table H-1

Summary of Physics Teacher Responses to Likert Items for Factor 1: Teachers' Beliefs and Attitudes on Multiculturalism (n= 22) continued

	Percentages		
Abbreviated Items	Agree	Neutral	Disagree
10. A person's cultural identity is as important as their individual identity.	77.3	9.1	13.6
11. It is important to identify the cultural backgrounds of my students.	63.6	15.9	20.5
12. Teachers benefit from having a basic understanding of diverse cultures.	100	0.0	0.0
13. It is important that content be framed in the context of students' cultural understandings.	76.2	0.0	23.8
14. The science classroom is an appropriate space to include multicultural perspectives.	81.0	14.3	4.8
15. Teachers should have experience working with students of diverse backgrounds.	81.0	4.8	14.3
16. There are just as many differences within cultures as there are between cultures.	95.5	0.0	4.5
17. Different cultural groups have different needs.	81.8	0.0	18.2
18. The cultural background of a teacher has an impact on students.	90.5	4.8	4.8

Note. Abbreviated versions of survey items are used for conciseness. See Appendix C for complete versions of the items.

Table H-2

Summary of Physics Teacher Responses to Likert Items for Factor 2: Cultural Norms in Curriculum and Instruction (n= 22)

	Percentages		
Abbreviated Items	Agree	Neutral	Disagree
19. Science curriculum reflects the contributions of many cultures.	38.1	14.3	47.6
20. Regardless of cultural differences, all students should be taught the same way.	9.5	9.5	81.0
21. Multicultural backgrounds are adequately represented in most curricular materials.	14.3	9.5	76.2
22. Cultural norms in America advantage certain populations.	100	0.0	0.0
23. Science curriculum generally reflects a modern Western / Eurocentric perspective.	81.0	14.3	4.8
24. It is difficult for people of multicultural backgrounds to become successful in America.	52.4	14.3	33.3
25. Only schools serving multicultural students need diverse staff.	0.0	9.5	90.5
26. It is the student's responsibility to make accommodations to overcome cultural barriers.	47.6	4.8	47.6
27. Cultural background should not impact performance because science is objective.	61.3	0.0	38.1
28. White students have more opportunities in mathematics and science than others.	47.6	9.5	28.6
29. Needs of multicultural students receive equal attention when compared to their White classmates (38).	61.9	9.5	28.6

Note. Abbreviated versions of survey items are used for conciseness. See Appendix C for complete versions of the items.

Table H-3

Summary of Physics Teacher Responses to Likert Items for Factor 3: Challenges and Concerns Related to Working with Students of Multicultural Backgrounds (n= 22)

	Percentages		
Abbreviated Items	Agree	Neutral	Disagree
30. Students of multicultural backgrounds often have greater difficulty with understanding science content.	19.0	19.0	61.9
31. Cultural diversity in a class makes it more difficult to teach science content.	23.8	9.5	66.7
32. Multicultural students are more likely to require remedial courses.	23.8	33.3	42.9
33. Sharing cultural perspectives takes away from time for content.	9.5	14.3	76.2
34. Culturally diverse students are less academically prepared for achievement in science.	42.9	9.5	47.6
35. I am less likely to contact a student’s home if there are cultural barriers between me and their parents.	25.0	15.0	60.0
36. I would prefer to work with students similar to mine.	14.3	9.5	76.2
37. White people place a higher value on education than other cultures.	0.0	19.0	81.0
38. Multicultural students are as likely to succeed in upper level and honors classes.	47.6	28.6	23.8
39. To become successful in America, people from multicultural backgrounds should adopt mainstream cultural practices.	38.1	19.0	42.9

(continued)

Table H-3

Summary of Physics Teacher Responses to Likert Items for Factor 3: Challenges and Concerns Related to Working with Students of Multicultural Backgrounds (n= 22) continued

Abbreviated Items	Percentages		
	Agree	Neutral	Disagree
40. Multicultural education is less important than reading, writing, arithmetic, and computer literacy.	33.3	9.5	57.1
41. All students, regardless of cultural background, should be held to the same academic expectations.	90.5	0.0	9.5

Note. Abbreviated versions of survey items are used for conciseness. See Appendix C for complete versions of the items.

Table H-4

Summary of Physics Teacher Responses to Likert Items for Factor 4: Instructional Practices (n= 22)

Abbreviated Items	Percentages		
	Agree	Neutral	Disagree
42. Students from different cultural backgrounds learn better from different methods of instruction.	66.7	23.8	9.5
43. I make changes to my instruction to address cultural differences.	57.1	14.3	28.6
44. Science instruction should have a focus on understanding inequities and cultural differences.	33.3	38.1	28.6
45. I include content related to the backgrounds of multicultural students.	57.1	19.0	23.8
46. Science instruction should have a focus on taking social action to address inequities and cultural differences.	47.6	19.0	23.8
47. It is the teacher's responsibility to address cultural barriers to understanding content.	90.5	4.8	4.8
48. A student's cultural background correlates to performance in science.	71.4	9.5	19.0
49. Multicultural education is most beneficial for students of multicultural backgrounds.	0.0	19.0	81.0

Note. Abbreviated versions of survey items are used for conciseness. See Appendix C for complete versions of the items.

Table H-5

Summary of Physics Teacher Responses to Likert Items for Factor 5: Teacher Preparation (n= 22)

	Percentages		
Abbreviated Items	Agree	Neutral	Disagree
50. I feel adequately prepared to teach students of diverse cultural backgrounds.	84.0	8.0	8.0
51. Upon reflection of my responses to the survey, I feel adequately prepared to teach students of diverse cultural backgrounds.	90.5	0.0	9.5
52. I meet with other teachers or staff to address contacting homes if there are cultural barriers between me and their parents.	95.2	0.0	4.8
53. Only schools serving multicultural students need a racially, ethnically, and culturally diverse faculty.	0.0	0.0	100

Note. Abbreviated versions of survey items are used for conciseness. See Appendix C for complete versions of the items.

Appendix I

Likert Item Responses of Earth Science Teachers on Survey on Multiculturalism in the Science Classroom

Table I-1

Summary of Earth Science Teacher Responses to Likert Items for Factor 1: Teachers' Beliefs and Attitudes on Multiculturalism (n= 19)

	Percentages		
Abbreviated Items	Agree	Neutral	Disagree
1. It is important to celebrate cultural diversity.	84.2	5.3	10.5
2. Everyone should be knowledgeable about the cultural practices of others.	89.5	5.3	5.3
3. It is important to recognize the contributions different cultures Have made to the culture of America.	94.7	0.0	5.3
4. Having cultural diversity in my class benefits everyone.	94.1	0.0	5.9
5. All students should be encouraged to learn about the practices of other cultures.	88.9	5.6	5.6
6. Students benefit from an understanding of diverse cultures.	100.0	0.0	0.0
7. People should develop meaningful friendships with people of different racial/ethnic groups.	89.5	10.5	0.0
8. White people should learn about diverse cultural backgrounds.	94.4	5.6	0.0
9. Opportunities for students of multicultural backgrounds enrich the experience for all students.	100.0	0.0	0.0

(continued)

Table I-1

Summary of Earth Science Teacher Responses to Likert Items for Factor 1: Personal Beliefs and Attitudes on Multiculturalism (n= 19) continued

Abbreviated Items	Percentages		
	Agree	Neutral	Disagree
10. A person's cultural identity is as important as their individual identity.	89.5	5.3	5.3
11. It is important to identify the cultural backgrounds of my students.	85.7	4.8	9.5
12. Teachers benefit from having a basic understanding of diverse cultures.	100.0	0.0	0.0
13. It is important that content be framed in the context of students' cultural understandings.	76.5	0.0	23.5
14. The science classroom is an appropriate space to include multicultural perspectives.	72.2	11.1	16.7
15. Teachers should have experience working with students of diverse backgrounds.	88.2	11.8	0.0
16. There are just as many differences within cultures as there are between cultures.	100.0	0.0	0.0
17. Different cultural groups have different needs.	94.7	0.0	5.3
18. The cultural background of a teacher has an impact on students.	94.1	5.9	0.0

Note. Abbreviated versions of survey items are used for conciseness. See Appendix C for complete versions of the items.

Table I-2

Summary of Earth Science Teacher Responses to Likert Items for Factor 2: Cultural Norms in Curriculum and Instruction (N= 19)

	Percentages		
Abbreviated Items	Agree	Neutral	Disagree
19. Science curriculum reflects the contributions of many cultures.	44.4	19.7	38.9
20. Regardless of cultural differences, all students should be taught the same way.	17.6	11.8	70.6
21. Multicultural backgrounds are adequately represented in most curricular materials.	22.2	22.2	55.6
22. Cultural norms in America advantage certain populations.	100.0	0.0	0.0
23. Science curriculum generally reflects a modern Western / Eurocentric perspective.	88.9	11.1	0.0
24. It is difficult for people of multicultural backgrounds to become successful in America.	61.1	11.1	27.8
25. Only schools serving multicultural students need diverse staff.	5.9	0.0	94.1
26. It is the student's responsibility to make accommodations to overcome cultural barriers.	17.6	5.9	76.5
27. Cultural background should not impact performance because science is objective.	50.0	11.1	38.9
28. White students have more opportunities in mathematics and science than others.	44.4	11.1	44.4
29. Needs of multicultural students receive equal attention when compared to their White classmates (38).	64.7	23.5	11.8

Note. Abbreviated versions of survey items are used for conciseness. See Appendix C for complete versions of the items.

Table I-3

Summary of Earth Science Teacher Responses to Likert Items for Factor 3: Challenges and Concerns Related to Working with Students of Multicultural Backgrounds (N= 19)

Abbreviated Items	Percentages		
	Agree	Neutral	Disagree
30. Students of multicultural backgrounds often have greater difficulty with understanding science content.	17.6	11.8	70.6
31. Cultural diversity in a class makes it more difficult to teach science content.	17.6	11.8	70.6
32. Multicultural students are more likely to require remedial courses.	41.2	11.8	47.1
33. Sharing cultural perspectives takes away from time for content.	11.8	11.8	76.5
34. Culturally diverse students are less academically prepared for achievement in science.	41.2	11.8	47.1
35. I am less likely to contact a student's home if there are cultural barriers between me and their parents.	5.9	5.9	88.2
36. I would prefer to work with students similar to mine.	5.9	11.8	82.4
37. White people place a higher value on education than other cultures.	16.7	11.1	72.2
38. Multicultural students are as likely to succeed in upper level and honors classes.	58.1	19.3	25.6
39. To become successful in America, people from multicultural backgrounds should adopt mainstream cultural practices.	27.8	22.2	50.0

(continued)

Table I-3

Summary of Earth Science Teacher Responses to Likert Items for Factor 3: Challenges and Concerns Related to Working with Students of Multicultural Backgrounds (N= 19) continued

	Percentages		
Abbreviated Items	Agree	Neutral	Disagree
40. Multicultural education is less important than reading, writing, arithmetic, and computer literacy.	27.8	11.1	61.1
41. All students, regardless of cultural background, should be held to the same academic expectations.	82.4	0.0	17.6

Note. Abbreviated versions of survey items are used for conciseness. See Appendix C for complete versions of the items.

Table I-4

Summary of Earth Science Teacher Responses to Likert Items for Factor 4: Instructional Practices (N= 19)

Abbreviated Items	Percentages		
	Agree	Neutral	Disagree
42. Students from different cultural backgrounds learn better from different methods of instruction.	55.6	22.2	22.2
43. I make changes to my instruction to address cultural differences.	64.7	17.6	17.6
44. Science instruction should have a focus on understanding inequities and cultural differences.	52.9	5.9	41.2
45. I include content related to the backgrounds of multicultural students.	70.6	17.6	11.8
46. Science instruction should have a focus on taking social action to address inequities and cultural differences.	70.6	0.0	29.4
47. It is the teacher's responsibility to address cultural barriers to understanding content.	88.2	0.0	11.8
48. A student's cultural background correlates to performance in science.	50.0	16.7	33.3
49. Multicultural education is most beneficial for students of multicultural backgrounds.	22.2	0.0	77.8

Note. Abbreviated versions of survey items are used for conciseness. See Appendix C for complete versions of the items.

Table I-5

Summary of Earth Science Teacher Responses to Likert Items for Factor 5: Teacher Preparation (N= 19)

	Percentages		
Abbreviated Items	Agree	Neutral	Disagree
50. I feel adequately prepared to teach students of diverse cultural backgrounds.	81.8	0.0	18.2
51. Upon reflection of my responses to the survey, I feel adequately prepared to teach students of diverse cultural backgrounds.	82.4	0.0	17.6
52. I meet with other teachers or staff to address contacting homes if there are cultural barriers between me and their parents.	64.7	23.5	11.8
53. Only schools serving multicultural students need a racially, ethnically, and culturally diverse faculty.	5.6	0.0	94.4

Note. Abbreviated versions of survey items are used for conciseness. See Appendix C for complete versions of the items.