# FACILITATING CULTURAL BORDER CROSSING IN URBAN SECONDARY SCIENCE CLASSROOMS: A STUDY OF INSERVICE TEACHERS

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ABSTRACT

Facilitating Cultural Border Crossing in Urban Secondary Science Classrooms:

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Research acknowledges that if students are to be successful science, they must learn to navigate and cross cultural borders that exist between their own cultures and the subculture of science. This dissertation utilized a mixed methods approach to explore how inservice science teachers working in urban schools construct their ideas of and apply the concepts about the culture of science and cultural border crossing as relevant to the teaching and learning of science. The study used the lenses of cultural capital, social constructivism, and cultural congruency in the design and analysis of each of the three phases of data collection. *Phase I* identified the perspectives of six inservice science teachers on science culture, cultural border crossing, and which border crossing methods, if any, they used during science teaching. *Phase II* took a dialectical approach as the teachers read about science culture and cultural border crossing during three informal professional learning community meetings. This phase explored how teachers constructed their understanding of cultural border crossing and how the concept applied to the teaching and learning of science. *Phase III* evaluated how teachers' perspectives changed from *Phase I*. In addition, classroom observations were used to determine whether teachers' practices in their science classrooms changed from *Phase I* to *Phase III.* All three phases collected data through qualitative (i.e., interviews, classroom observations, and surveys) and quantitative (Likert items) means.

The findings indicated that teachers found great value in learning about the culture of science and cultural border crossing as it pertained to their teaching methods. This was not only evidenced by their interviews and surveys, but also in the methods they used in their classrooms. Final conclusions included how the use of student capital resources (prior experiences, understandings and knowledge, ideas an interests, and personal beliefs), if supported by science practices and skills increases student cultural capital. With a greater cultural capital, the students experience cultural congruency between their cultures and the culture of science, enabling them to cross such borders in the science classroom. The implications such findings have on teacher training programs and professional development are discussed.

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# DEDICATION

I would like to dedicate this manuscript to all my students; young and old, past, present and future. I hope to have inspired you, as you have and continue to inspire me.

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# CHAPTER I

# INTRODUCTION

As a science educator in an urban district, I have seen firsthand the struggles students face when trying to learn science. While many of my colleagues would argue that the students' lack of preparation, poor study habits, and disruptive family lives cause this disconnect, I believe the problem lies in the borders that exist between the culture of science and the students' own culture and lifeworlds. Although this is not a new theory in the field of science education and many note that teachers should be aware of these borders (Aikenhead, 1996, 2001; Aikenhead & Jegede, 1999; Costa, 1995; Phelan, Davidson, & Cao, 1991), little research in the United States offers potential solutions for how teachers can facilitate students' abilities to border cross.

Science teachers struggle in reaching all urban science students in a meaningful and culturally relevant way (Barton & Upadhyay, 2010; Lee, 2003; Tobin, 2006, 2010). Urban teachers must learn to capitalize on the diversity that exists in their classrooms and apply it to their science instruction in culturally appropriate ways. It is essential to prepare science teachers, especially urban science teachers, to learn to teach in these ways (Mensah, 2011). This study aims to identify how teachers learn about the cultural borders that exist in their science classrooms and what methods work best in helping to facilitate students across such borders.

## Purpose and Research Questions

This study used cultural capital, cultural congruency, and social constructivist perspectives to examine how teachers learned to facilitate cultural border crossing between students' lifeworlds and the world of science. There were three aims to this qualitative study. The first was to identify teachers' perspectives on the culture of science and cultural border crossing. The second aim was to investigate how teachers responded to learning about the culture of science and cultural border crossing in an informal professional learning community (PLC) forum. The final aim of the study was to identify the strategies science teachers used to facilitate border crossing and their effect on classroom culture.

The research is clear in that students who can cross cultural borders into the culture of science are more likely to succeed in the field (Aikenhead, 1996, 2001; Aikenhead & Jegede, 1999; Phelan et al., 1991). However, what is not commonly discussed in the literature are the perspectives teachers have, how they respond when they learn about such borders, and what methods are most successful in helping students cross these borders. The following research questions aim to address how urban science teachers can better facilitate cultural border crossing.

1. What perspectives do urban secondary science teachers have regarding the culture of science and cultural border crossing and their role in science education?
2. How do urban secondary science teachers respond to learning and discussing the notion that science is a subculture and that students must learn to border cross?
3. How does awareness and understanding of science culture and cultural border crossing influence urban secondary science teachers':
    a. perspectives regarding the culture of science and cultural border crossing and their role in science education and,
    b. their teaching practices and classroom culture?

## Role of the Researcher

I, the researcher of the study, acted primarily as a participant observer. I interviewed the participants, administered the surveys, and performed classroom observations. I worked closely with the participating teachers in the few years leading up to the study as they developed their practice and refined their teaching method. I mentored Fabio, Joshua, Gabriella and Sasha at some capacity during their teaching residency and/or first year of teaching. However, at the time of the study, I was not a mentor to any of the participants nor did I have any influence on their evaluations or ratings. As a lead teacher in the department, my role was specifically to support all department teachers in the planning and implementing of their lessons and running common planning meetings. These meetings, sometimes facilitated by myself and other times by other department members, including some of the participants, consisted of discussions around student engagement, developing lessons, and creating common assessments. This offered me a great deal of insight and knowledge regarding the teachers, their classroom and the cultural norms within the department, a benefit as a participant researcher.

Although this provided me with a more in-depth understanding of their roles in the school and classroom, it may have also influenced their practice as growing educators. Having worked so closely with several of the participants and as an acting leader within the science department may have impacted the participants' ability to grasp and apply the concepts of cultural border crossing. Additionally, my role as a trusted colleague and researcher and knowing that I came into this study with a distinct new belief regarding cultural border crossing influenced the implementation and findings of this study.

As a member of the school community and teacher leader in the department for 7 years, I had a thorough understanding of the school environment, culture, and student population. Additionally, my experiences as a secondary science teacher in the school allowed me to witness firsthand the struggle students encounter when crossing such borders into the culture of science. Finally, as I was immersed in the school's day-to-day activities, my insights about the school, its student population, and the science department enhanced the results of this study.

# CHAPTER II

# LITERATURE REVIEW

In this chapter I discuss the literature relating to the study. I begin by first describing the need for multicultural science education followed by a review of the literature discussing the subculture of science and its relevance to the teaching and learning of science, especially through a border crossing lens. Literature surrounding the topic of professional learning communities is reviewed. Finally, the theoretical frameworks of cultural capital, cultural congruency, and constructivism are discussed.

## Science Education for Diverse Populations

The notion of multicultural education is not new in the field. Banks (1993) and Nieto (1999) identified the 1960s as the point in educational history when multicultural education got its start in the literature, primarily regarding issues of multiculturalism in textbooks. The notion first came about with the civil rights movement and was later encouraged during the women's rights movement of the late 1960s and early 1970s (Banks, 1989). It was in the early 1970s that researchers began devising standards to evaluate textbooks in terms of multiculturalism, and in 1979, multicultural teacher education was first adopted by the National Council for Accreditation of Teacher Education (NCATE). Soon after, multiculturalism was implemented as a standard in many teacher preparation programs. It was Banks (1993) who divided the evolution of multicultural education into the following phases: ethnic or single group studies; multiethnic education; other disaffected groups need for inclusion; and the development and integration of theory, research, and praxis.

As student diversity increases in public schools, the research to better support these students throughout their learning, in particular multicultural science teacher education, is necessary. The need to expand and improve upon research in science education for diverse populations has been a growing area in science education over the last 20 years and it was Atwater (1996b) who was one of the first to call for a research agenda that aimed to address these issues. Her work and the work of other leading multicultural researchers was responsible for making great strides in the field by questioning and pushing the debate on urban and multicultural education in science (Aikenhead, 1996; Barton & Upadhyay, 2010; Lee, 2003; Tobin, 2005). They have provided practitioners and scholars with a thorough framework to best support learning in such settings.

## The Culture of Science

Culture has been defined by many scholars (e.g., Aikenhead, 1996; Geertz, 1973; Nieto, 1999). Sonia Nieto (1999) defined culture as “the ever-changing values, traditions, social and political relationships, and worldview created, shared, and transformed by a group of people bound together by a combination of factors that include common history, geographic location, language social class and religion”(p. 48). Many argue that Western science is a subculture of Western culture (Jegede, 1994; Maddock, 1981; Meyer & Crawford, 2011; Ogawa, 1995; Snively & Corsiglia, 2001) that has norms, values, beliefs, and expectations that are generally shared among its members (Aikenhead, 1996).

This subculture of science, Shizha (2007) argued, “is a culture for the privileged, hence a closed culture which is not open to everybody” (p. 305). As such, science often seems foreign to the vast majority of students (Aikenhead, 1996; Atwater & Riley, 1993; Costa, 1995; Lee, 2004; Ogawa, 1995) and may discourage students from participating in school science (Brand, Glasson, & Green, 2002). Costa (1995) and Jegede (1995) claim that the differences that exist between the culture of science and students’ home cultures are a leading cause for this foreignness. Therefore, the learning of science is a form of culture acquisition where the student must learn the practices and characteristics of the science subculture (Krogh & Thomsen, 2005).

## Border Crossing

### Definition and Distinguishing Features

It was Phelan et al. (1991) who first discussed the boundaries that exist between students' lifeworlds and school culture. Furthermore, they explored the patterns that exist when students transition between different "worlds" such as the subcultures of their personal lives and school. They use the terms "*boundaries* and *borders* [to] refer to the real or perceived lines or barriers between worlds" (p. 225). Their study of 54 students in urban California suggested that students transition between these worlds or subcultures with varying degrees of ease. Phelan et al.'s typology proposed four patterns in which students transition between these worlds:

- Type I: congruent worlds/smooth transitions
- Type II: different worlds/border crossings managed
- Type III: different worlds/border crossings difficult
- Type IV: different worlds/borders impenetrable (p. 228)

According to Phelan et al. (1991), students who follow a Type I pattern have smooth transitions once they encounter a border. For these students, the "values, beliefs, expectations, and normative ways of behaving are, for the most part, parallel across both worlds" (p. 229). For students who follow a Type II pattern, the borders are more difficult due to a difference in the students' "culture, ethnicity, socioeconomic status, or religion" (p. 232). However, for Type II students, crossing such borders is manageable with a little adjustment. A Type III pattern occurs when students' two worlds (family/personal and school) are different. This is unlike the Type II students, who are able to navigate these two worlds, Type III students experience "hazardous transition[s]" (p. 237) as they attempt to reorient themselves between their different worlds. Finally, the Type IV pattern transpires when students' worlds of school and family are too different from one another. After continuous unsuccessful attempts to cross such borders, students begin to perceive these borders as impenetrable and will likely give up on their efforts.

While Phelan et al. (1991) were developing their study, educational theorist Henry Giroux (1992) discussed the notion of border and boundary crossing between cultures and subcultures and its relevance to education. In his book, Giroux uses modernism, postmodernism, and feminism as lenses to argue that cultural transitions are critical and uses the notion of border crossing to define this process. He discussed border pedagogy as offering students the opportunity to engage in different "cultural codes, experiences, and languages" (p. 29) and construct their own narratives and histories using their own cultures and learned cultures.

It was Costa (1995) who later applied Phelan et al.'s (1991) model to her study of 43 high school students enrolled in science courses. In studying these students' transitions between their worlds of family, peers, and school and the connections between these transitions and the students' success in the science classroom, Costa identified five patterns:

- Potential scientists: worlds of family and friends are congruent with worlds of both school and science
- Other smart kids: worlds of family and friends are congruent with world of school but inconsistent with world of science
- I don't know students: worlds of family and friends are inconsistent with worlds of both school and science
- Outsiders: worlds of family and friends are discordant with worlds of both school and science

- Inside outsiders: worlds of family and friends are irreconcilable with world of school but potentially compatible with world of science (p. 316).

It was later argued by Aikenhead (2001) that there is a sixth group of students that he called the “I want to know” students. This sixth category of students was as interested in science as the potential scientists mentioned by Costa (1995), but these students find science intimidating. These are generally students who would be expected to succeed in science but for some reason they are deterred from the field for a variety of factors that make science daunting.

**Border Crossing and Science Education**

Founding his work under the assumption that science is a subculture, Aikenhead (1996) used the works of both Costa (1995) and Phelan et al. (1991) to support the notion of cultural border crossing in the science classroom and considered the learning of science to be a cross-cultural event for many students, especially those he called nonmainstream science learners. Central to his perspective, he first distinguished between the enculturation and assimilation of cultural transmission. He argued that:

> If the subculture of science generally harmonizes with the student’s life-world culture, science instruction will tend to support the student’s view of the world (“enculturation”). On the other hand, if the subculture of science is generally at odds with a student’s life-world culture, science instruction will tend to disrupt the student’s view of the world by trying to replace or marginalize it, (“assimilation”). (Aikenhead, 1996, p. 4)

The notion of cultural border crossing relative to science education was later built upon by Aikenhead and Jegede (1999) as they studied the cognitive conflict that exists when students negotiate between the cultural borders of science and their own worlds. They found that there are some characteristics that are representative of successful border crossing, like a "sense of flexibility, playfulness, and/or feelings of ease" (p. 274). Aikenhead (2001) later argued that the learning of science is a form of collateral learning that is dependent on the differences between the culture of science and students' cultural identities as well as the effectiveness by which students negotiate these borders.

**Science Teaching and Learning for Urban and Marginalized Students**

The teaching and learning of science in urban schools for traditionally marginalized populations has been studied by many in science education (Atwater, 1993; Lee, 2003; Lee & Buxton, 2011; Tobin, 2005, 2006). It is evident that students in urban districts are underperforming in science (National Center for Education Statistics, 2009). This substandard performance of nonmainstream students is argued by Lee and Buxton (2011) to be due to school science being irrelevant and non-engaging, rather than due to students' inability to perform well. Alston (2004) supports this notion and stated, "cultural, racial, economic, linguistic, and other borders must be crossed to ensure that the ever-changing demographic of public schools is considered in efforts to create effective centers of learning that facilitate the academic success of all students" (p. 80).

The elite culture of science continues to be discussed as oppressive and aligning more effectively with the culture of mainstream students, generally White upper- and middle-class students (Aikenhead, 2001; Emdin, 2010b; Lee, 2003; Lee & Buxton, 2011; Tobin, Elmesky, & Seiler, 2005). It has estranged minority students from engaging (Atwater & Riley, 1993; Emdin, 2010a, 2010b) and has alienated and disempowered them because of their inability to enact their own culture as they learn science (Tobin, 2006). These students are often confused and frustrated by societal induced barriers that challenge their ability to negotiate these borders (Brand et al., 2002).

It has also been argued that education is not only racialized but also genderized (Alston, 2004; Brotman & Moore, 2008). Alston related the notion of gender equity in education to a bicultural interaction. With this notion in mind, females, and especially minority females, must learn to be successful border crossers as well. As teachers and the culture of science continue to oppress minority, non-mainstream, and female students, we only perpetuate oppressive behavior. This oppressive behavior was discussed by Paulo Freire (1970) who wrote, "This is a tragic dilemma of the oppressed which their education must take into account" (p. 48).

Students representing diverse cultural and ethnic backgrounds are crossing cultural borders as they enter science classrooms (Aikenhead, 1996, 2001), more so than mainstream students whose cultural contexts, communication styles, and beliefs are better aligned to the culture of science (Lee & Buxton, 2011). A true challenge that minority students face is the disconnect that exists between their home languages and cultures and the culture and language of school science (Atwater, 1994; Cobern & Aikenhead, 1998; Lee, 1999). This can be exaggerated depending on the content area as described in Krogh and Thomsen's (2005) study of physics students and their ability to border cross. When properly facilitated through equitable opportunities, minority students can take advantage of their experiences, both linguistic and cultural, and use them as resources for learning science (Lee, 2003).

Aikenhead (1996, 2001) argued that non-mainstream students must enculturate into the culture of science by acquiring not only the skills and understandings, but also the beliefs, values, attitudes, and actions of the science culture. In order to create an ideal school environment for the increasingly diverse populations science educators are faced with, Phelan et al. (1991) suggest understanding students' multiple worlds to help identify how students negotiate the borders successfully.

## The Teacher and Border Crossing in the Science Classroom

### Role of the Teacher in Border Crossing

Introduced early in the field of education by Wyatt (1978), the notion of teachers as cultural brokers defines how educators can act as facilitators of border crossings. Similarly, Giroux (1992) argued the need for cultural workers, or teachers, in the classroom to facilitate the movement between borderlands. This concept of cultural worker and broker was then applied to the learning of science by helping students negotiate the transitions between their own cultures and the culture of science (Aikenhead, 1996, 1999, 2001; Aikenhead & Jegede, 1999).

The use of the border crossing concept as related to the field of science education provides educators and educational leaders with a perspective that the learning and understanding of science is not exclusive or selective (Brand et al., 2002). It supports Phelan et al.'s (1991) emphasis on fostering a school environment where students' differences are valued rather than feared. Considering border crossing in education helps educators to understand where their students come from and the unique experiences they bring to the classroom while being aware of the larger issues related to diversity (Alston, 2004).

Wyatt (1978) and others have argued that the cultural congruence between school world and student's lifeworld is dependent on the teacher and students sharing similar linguistic and cultural backgrounds (Au, 1998). Other researchers argue that effective instruction from a border crossing perspective can take place so long as the teacher understands the students' linguistic and cultural backgrounds (Ladson-Billings, 1994, 1995; Lee, 2003).

The cultural clashes that exist between the world of Western science and students' lifeworlds have brought forth several suggestions for improving science curriculum and refining teaching practices in a more culturally sensitive way. Aikenhead and Jegede (1999) propose that teachers should first recognize science as being its own culture with individual practices, values, and beliefs and in turn acknowledge the borders that students must cross to learn and participate in science successfully. They also suggest that teachers assist students in negotiating these borders and help resolve any cultural conflicts. Although these are suggestions, there is no literature on how to apply these suggestions in the classroom or how to prepare teachers to be cultural brokers or cultural workers in the teaching and learning of science.

## A Professional Learning Community (PLC) Approach to Understanding Border Crossing

As mentioned above, currently there is little research or literature that describes how teachers learn about the notions of the culture of science and cultural border crossing in the science classroom. This being said, it is evident that in order for science teachers to establish methods of facilitating border crossing they must first obtain an understanding of this concept. For the purpose of this study, an informal professional learning community (PLC) was established to provide the participants of the study a forum to discuss and develop their understandings of border crossing. Although there are many definitions of the PLC, they all center around groups of teachers, often within a department or grade level working collaboratively, where teachers share and build on each other's knowledge to broaden their understanding of and refine their practice through reflection and student outcomes. PLC's emphasize the development of teachers and their practices by focusing on teacher learning through reflection in a community centered setting (McLaughlin & Talbert, 2006). This section discusses the history of professional development in the United States, then transitions into a discussion regarding the benefits and uses of PLC as a method of professional development, and finally concludes with a review of literature on how teachers learn through a multicultural perspective.

**From Professional Development to PLC**

Originally conceived to help bridge the gap in literacy and mathematics skills, Title IX of the Elementary and Secondary Education Act of 1965, was created by the U.S. Department of Education. It was with Title IX that funds and attention were focused on building, sustaining, and improving professional development for teachers in the classroom. More recently, the same notions regarding professional development have been redesigned and amended via the No Child Left Behind Act of 2001 to hold educators and educational administrators accountable at the school level for development that best supports student achievement. Currently, most states, including New Jersey where the study takes place, are required to make professional development opportunities available for teachers (Mizell, 2010).

In 1996, Darling-Hammond and McLaughlin recommended that there be a shift in the way in which we develop teachers. Their recommendations included the use of collaborative and inquiry style learning in a space where teachers solve problems, revise ideas and methods, and set new goals (Darling-Hammond & McLaughlin, 1996). One form of professional development to achieve such goals is through the use of a PLC. The National Staff Development Council defines PLC as “Professional learning that increases educator effectiveness and results for all students occur within learning communities committed to continuous improvement, collective responsibility, and goal alignment” (Mizell, 2008, p. 1).

**Professional Development for Novice Science Teachers**

It is recommended by the National Science Teachers Association (NSTA) that "to facilitate the on-going development of science educators, induction programs should focus on the unique nature of teaching science, including the role of inquiry and other standards based instructional approaches that promote the learning of particular scientific concepts and skills. . ." (2007, p.1). Feiman-Nemser (2001), discusses the critical paradox that science teachers experience during their first three years of teaching. She explained that new teachers are expected to demonstrate a skill base in their new jobs that they have yet to develop and will only develop fully after gaining experience. She further explains that this paradox is only exacerbated when coupled with the "complex, uncertain and full of dilemmas" (p.1028) that is innate in teaching.

NSTA (2007) makes several recommendations for a comprehensive induction program, however for the purpose of this study, three will used to support the methods of this study. They are as follows:

- The inclusion of a planned and intentional set of learning activities for mentees during the course of the program. This "induction curriculum" anticipates what mentees want and need to learn, and identifies the resources and activities necessary to support each mentee's growth and development. These resources and activities can take the form of modules, workshops, interactive group activities, tools for regular mentor/mentee collaboration, or combinations of these activities.
- The recognition of and commitment to the importance of creating a "culture of collaboration" within the school, as well as in the larger community of science educators,

where new and experienced teachers are encouraged to share ideas, discuss problems, and support and learn from each other to improve their practice.

- The ongoing collection of data about the development of the beginning teachers that can be used to interact with policy at different levels. Such data would assist policy makers, as well as induction program developments and the learning of students and teachers. (NSTA, 2007, p.2)

**Teacher Learning for Diverse Populations**

Although research on teaching science to diverse populations has improved over the years, there is still a need to prepare teachers and provide support to teachers to teach science in meaningful ways (Atwater, 2000; Furman, Barton, Muir, 2011). Luykx, Cuevas, Lambert, and Lee (2004) claim that many teachers view culture as irrelevant to the teaching and learning of science. Issues of diversity and multicultural education have become a standard course requirement in most teacher education programs. However, of these programs, many only require one course that generalizes the complex concepts, and few focus on the approaches most valuable to urban school teachers (Alston, 2004; McAllister & Irvine, 2000; Zeichner, 2003). Likewise, many staff development opportunities for inservice teachers address issues of race, culture, and ethnicity, but these are usually single day workshops with little to no follow up (Gay, 2000). Feiman-Nemser (2001) also argued that the two main forms of professional learning, mandated staff development and university coursework, are often unsuccessful in helping teachers transform complex knowledge and fail to follow up with teachers. In response to this notion, Furman et al. (2011) called for preparation and development for science educators to be focused on teaching science in a meaningful way for minority students, a vantage point that Aikenhead (1996) argues his framework in border crossing will support.

For teacher learning and development in the areas of subject matter knowledge, general pedagogical knowledge, pedagogical content knowledge, and knowledge of context (Grossman, 1990; Shulman, 1987), it is argued this can best be accomplished in teacher learning communities (Anyon, 1994). The formation of such learning communities "requires teachers to engage in both intellectual and social work-new ways of thinking and reasoning collectively as well as new forms of interacting interpersonally" (p. 973). Similarly, Feiman-Nemser (2001) argued that these learning communities are not promoted in traditional professional development. Instead, they are typically sporadic or disconnected with little follow-up and opportunity or time for application of newly learned concepts. These learning communities should strive to establish and promote what teachers attempt to develop in their classrooms, a community of learners. In doing so, teachers are able to share thoughts and beliefs, listen to each other, and focus on learning while still taking into consideration the needs of the group.

Anyon (1994) argued that the benefits of such communities within the school are substantial and can lead to effective teacher development. These arguments are taken into account in the method design of this study. When looking at teacher development from a cultural standpoint, a first step in supporting science teachers to work with diverse students is to have the teachers learn who they are as educators by being reflective of their own experiences, beliefs, histories, and racial and ethnic identities and defining the capital they bring into the classroom (Banks, 1993; Brand & Glasson, 2004; McAllister & Irvine, 2000; Mensah, 2009; Pajares, 1992; Waddell, 2011). These beliefs and self-understandings contribute greatly to teachers' pedagogical practices (Pajares, 1992).

Oftentimes, teachers use a deficit perspective when interpreting students' experiences, cultures, and identities. This perspective leads to inequitable educational opportunities (Atwater, 1994; Brand & Glasson, 2004; Ladson-Billings, 1999; Waddell, 2011) and challenges for students to overcome. To avoid this, teachers should "reveal, challenge, and change cultural modes that impede the development of equitable classrooms" (Moore, 2007b, p.105). Therefore, a next step after defining their self-identify would be to have urban science teachers reveal their beliefs and understanding about teaching diverse students (Mensah, 2009).

To address deficit perspectives, teachers should spend a significant amount of time learning about their students' cultures. This entails face-to-face encounters between students and teachers as well as teachers socializing in the urban community in which they teach to learn about the local issues related to the cultures, languages, ethnicities, races, and genders of their students (Gay, 2004; Ladson-Billings, 1994, 2001; Mensah, 2014; Moore, 2007a, 2007b; Tobin, 2006; Roth et al., 2004; Waddell, 2011, Zeichner, 2003). Studies show that these organic interactions are more effective in helping teachers understand the value of students' cultures and identities than workshops (Luykx et al., 2004) and help teachers understand how the capital students bring can be resourceful in building a more equitable learning experience (Emdin, 2010a; Tobin, 2005).

During this cultural learning period, Lee and Buxton (2010) suggest that teachers and teachers in training build trusting relationships with their students. This creates an ally relationship between the student and teacher, where together they can work against the oppressive nature of the science classroom culture. This was evident in Tobin's (2006) study where Alex, an urban teacher, was able to exchange social and symbolic capital to build the cultural capital necessary to teach science to his urban students. In turn, Alex earned the respect and appreciation of his students.

This study aimed to address the void in the literature regarding teachers' roles in facilitating cultural border crossings between students' lifeworlds and the culture of science. Efforts must be made to address this as much of the literature discusses (Aikenhead, 1996, 2001; Aikenhead & Jegede, 1999; Lee, 2003).

## Theoretical Framework

### Cultural Capital

It was Pierre Bourdieu and Jean Claude Passeron who first discussed the theories of cultural and social capital in education (1977). Their early perspective was one that focused on the application of cultural capital and less on the forms of capital (Bourdieu & Passeron, 1977). It was later that Bourdieu proclaimed that the system produces a culture that represents the dominant culture or the "ruling class" and that success within the system requires predisposed cultural and social competence gained from personal experiences in one's upbringing. He advocated that this notion of cultural capital was also relevant in school settings. Specifically, he concluded that students of different backgrounds whose capital was not aligned with that of the ruling class experienced a disparity in their ability to succeed. Furthermore, he argued that schools reward students whose capital is most aligned with that which is modeled by the schools (Bourdieu, 1984).

In 1986, Bourdieu discussed further the forms of capital as social, cultural, and economic and believed that "the construct of capital makes it possible to explain the unequal scholastic achievement of children originating from different social classes by relating to academic success" (p. 243). He suggested that although these ties may benefit a group, coincidentally they also bar other groups from access. He also focused his discussion on the three forms of cultural capital that exist: objectified, embodied, and institutionalized. Objectified capital refers to the tangible cultural objects that one possesses or acquires over time, or as Bourdieu would say, cultural goods. Embodied cultural capital refers to not only the capital that is inherited through family experiences and pedagogy but also to capital that is consciously acquired and is therefore the only form of cultural capital that is limited to life and familial experiences. Finally, institutionalized capital consists of the cultural capital one obtains through formal education and the degrees and credentials this provides (Bourdieu, 1986). How an individual or student internalizes these forms of capital is referred to as their habitus. One's habitus consists of that person's behaviors, conscious and subconscious cultural understandings, and beliefs, which ultimately influence their educational experiences (Bourdieu, 1984).

For the purpose of this study, data were analyzed through a cultural capital lens, which was described by Lewis (2003) as, "those sets of knowledge and skills valuable in a particular field of social setting" (p. 162). This perspective was selected as the theoretical framework for this study because it was most relevant to studying cultural borders that exist in science classrooms as a result of the elite culture of science.

A common theme when analyzing cultural capital is the need for, and use of, resources in determining each form of capital, "economic (money and poverty), social (connections, social networks), cultural (cultural knowledge, educational credentials), and symbolic (symbols of prestige and legitimacy)" (Lewis, 2003, p. 155). To Yosso (2005), these resources can be obtained from one's family and/or from formal schooling. For example, a students' cultural capital as it relates to their schooling, is often influenced by the educational experiences, credentials, and cultural knowledge their parents and family exhibit. Rivera Maulucci (2010) applied these concepts of capital resources to her study of resisting marginalization of science urban schools. She concluded that attention to these resources "illuminates the ways that struggle for social justice in science education is an individual and collective process" (Rivera Maulucci, 2010, p. 857). Nevertheless, it is critical to note that many have argued that it is not only the resources people have available to them that earns them capital, but rather whether they effectively use their resources to their benefit (Lareau, 1989; Lareau & Horvat, 1999; Lewis, 2003).

The use of cultural capital is highly applicable when studying a school setting because of the behaviors and skills required for being successful in school science. Watson (2011) used a similar framework in her analysis of urban educators. The cultural capital that the teachers bring into the classroom and the resources they use to be successful in teaching science are used to analyze the borders that students encounter when learning science.

**Cultural Congruency**

Many researchers have addressed the need for pedagogies that support culturally and linguistically diverse students and have coined terms related to this need like culturally relevant (Ladson-Billings, 1994, 1995), culturally sustaining (Paris, 2012), culturally appropriate (Au & Jordon, 1981), culturally compatible (Jordan, 1985), and culturally responsive (Gay, 2000). It was Lee and Fradd (1998) who proposed the concept of instructional congruence as "the process of mediating the nature of academic content with students' language and cultural experiences to make such content (e.g., Science) accessible, meaningful, and relevant for diverse students" (p. 12). Their description of instructional congruence focused on the teacher as a mediator between academic disciplines and their students' cultures, languages, and identities (Lee & Fradd, 1998).

Later, studies in science education brought forth a similar notion of cultural congruence but also focused on culturally meaningful instruction, classroom environment, and content (e.g., Gay, 2000). In their study of physics students' attitudes toward science and their success within the science classroom, Krogh and Thomsen (2005) used this notion of congruence as a key factor in determining students' ability to border cross between the culture of science and their own worlds. Similar studies have also used the notion of cultural congruence in examining minority student success in science fields (Cole & Epinoza, 2008), and others have studied minority students' perceptions of their university using an instrument called the Culturally Congruent Scale (Devlin, 2011; Gloria & Kurpius, 1996). More recently, Dutch researchers, Taconis and Kessels (2009), argued that a student's decision to specialize in science is often dependent on the culture of science itself and how congruent it is to that student's identity.

**Constructivism and Social Constructivism**

Initially emerging from the radical constructivist theory, social constructivism entails the contributions of social exchanges and interactions (Vygotsky, 1978). Social constructivists, however, believe that new meanings or making meaning of a phenomenon within a certain social and cultural context are processes of knowing (Atwater, 1996b). This is a critical issue in education as the focus is not solely on whether students are constructing knowledge, but rather *how* they construct this knowledge. Cobb (1994) argues the nature of the social and cultural interactions that influence the construction of knowledge. According to Atwater (1996b), students of science education can construct and acquire knowledge through these social interactions as well as when their inner states are accurately represented by the existing state of the external scientific world.

Additionally, it is argued by Driver, Asoko, Leach, Scott, and Mortimer (1994) that science learning not only requires these social interactions, but also requires the introduction of the cultural tools of science. They argue that, "learning science in the classroom involves children entering a new community of discourse, a new culture" (p. 11). This statement supports

Solomon's (1983, 1987) position that learning science concepts is a process of socially negotiating meaning between science learners' lifeworlds and the world of science. The authors believe that through this social constructivist lens, educators must introduce methods of making personal sense of the ways to view the world and this new culture (science). Thus, research through this lens in science education should focus on making meaning by having the students involved and engaging in teaching and learning science and is expected to be a factor in successful border crossing.

Finally, the constructivist perspective was used in the design of the methods of this study, specifically during *Phase* II. The PLC in *Phase II* used a constructivist approach as teachers applied their prior knowledge, experiences, and reflections and built upon new ideas. The teachers use a reflective process as they build upon new ideas in constructing an understanding of cultural border crossing and its application in the teaching and learning of science.

# CHAPTER III

# METHODS

In this chapter I discuss the methods by which data was collected and analyzed. Data were collected in three phases with each phase aligning to a specific research question. The specifics of each phase, data source, and analysis methods are discussed.

## Overview of the Research Approach

To address each of the three research questions, data was collected in three phases, triangulated, and then analyzed after each phase. Table 3.1 provides an overview of the research questions and their corresponding data sources.

Table 3.1
*Summary of Research Questions and Their Corresponding Data Sources*

| Research question | Data collection procedure |
|---|---|
| 1. What perspectives do urban secondary science teachers have regarding the culture of science and cultural border crossing and their role in science education? | *Phase I:*<br>• Interview<br>• Survey (qualitative and quantitative)<br>• Classroom observations/field notes |
| 2. How do urban secondary science teachers respond to learning and discussing the notion that science is a subculture that their students must learn to border cross? | *Phase II:*<br>• Observations/field notes during learning sessions<br>• Teacher discussion questions |
| 3. How does awareness and understanding of science culture and cultural border crossing influence urban secondary science teachers'<br>a. perspectives regarding the culture of science and cultural border crossing and their role in science education and,<br>b. their teaching practices? | *Phase* III:<br>• Interview<br>• Survey (qualitative and quantitative)<br>• Observations |

Most of the data sources were in qualitative form, while quantitative data was collected from six five-point Likert scale items on the surveys in *Phase I* and *Phase III*. This supported the concurrent embedded mixed methods approach where qualitative and quantitative data were integrated and collected congruently then merged to provide a more descriptive analysis that supports the quantitative results. The primary method, qualitative, guided the research study while the secondary method, quantitative, "provide[d] a supporting role" (Creswell, 2009, p. 214) in the procedures and data analysis during *Phases I* and *III.* The purpose for selecting this strategy was to provide a broader perspective in the results as opposed to only using the dominant method and to "increase the interpretability, meaningfulness, and validity" (Plano Clark & Creswell, 2008, p. 127).

The qualitative components of this study used a critical ethnographic approach. As a lead science teacher in the participating school, I was immersed in the behavior, beliefs, and languages of the cultural sharing group being studied, the City High (adopted pseudonym) science department, following Creswell's (2007) requirements of ethnography. More specifically, since this study took place in an urban school where the majority of the student population represented marginalized groups, it is classified as a critical ethnography (Creswell, 2007). I was a member of the cultural sharing group and aimed to advocate the benefits of facilitating cultural border crossing in science classrooms with diverse student populations. This qualitative approach was most appropriate for this study because it aimed to seek a detailed understanding from within a small sample. A summary of the data sources can be found on Figure 3.1.

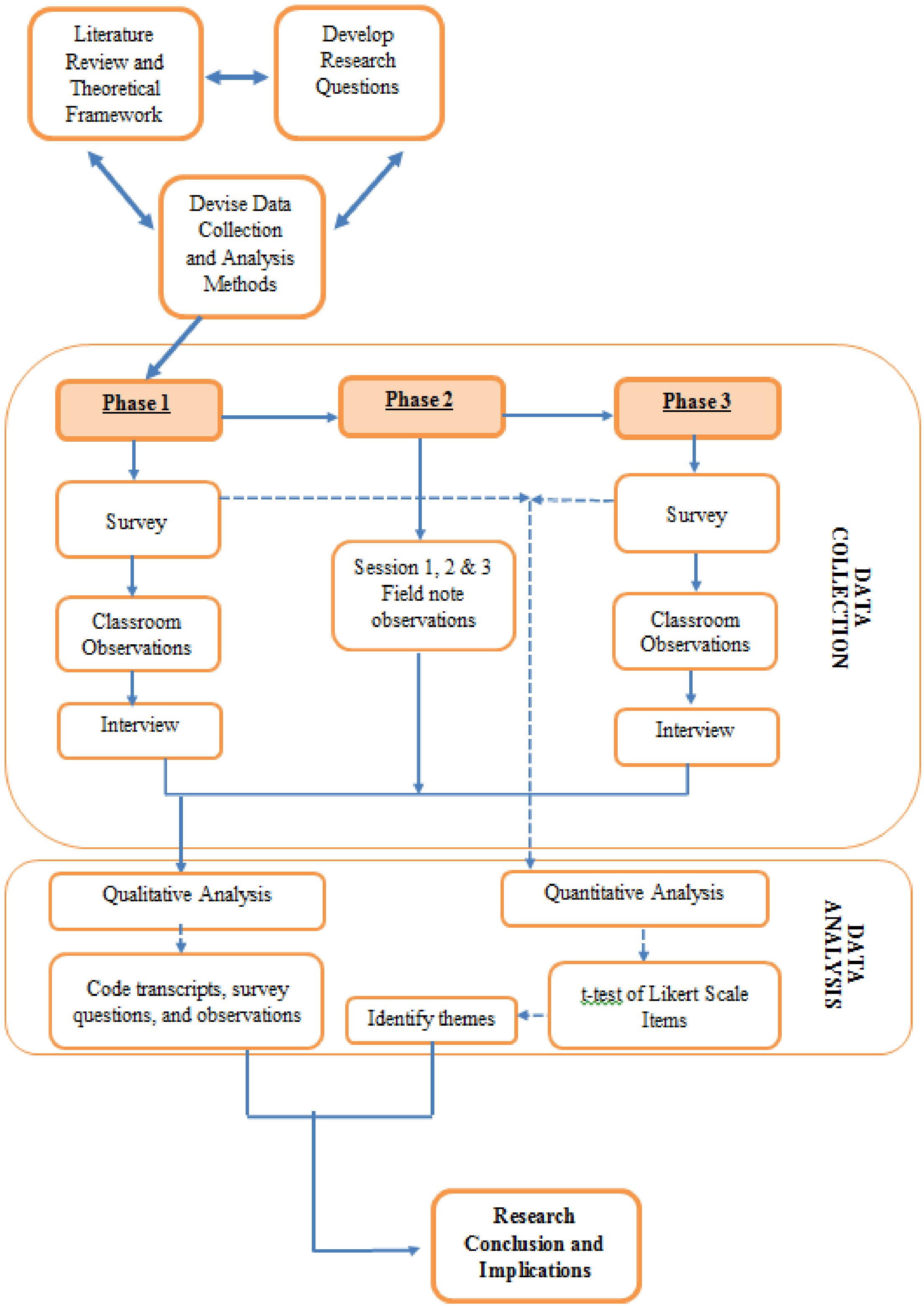


*Figure 3.1*. Research plan depicting how multiple data sources were collected and analyzed.

## Setting and Participants

### Field Setting

The study took take place in a large comprehensive high school in the largest urban district in New Jersey. The high school served approximately 1,800 students and was led by a single principal, 13 Content and Cultural Vice Principals, and 108 teachers. City High School was known to be a very diverse high school with over 50 countries represented and 14 different languages spoken by the student population, making it a model location for the proposed study. The two primary languages spoken at the school were Spanish and Portuguese, making up 38.2% and 20.0% of the overall population, respectively. Additionally, the school was known for its extensive and highly regarded bilingual Portuguese and Spanish programs. Enrollment for each of the subgroups as defined by the No Child Left Behind Act of 2001 identified City High School as being 50.4% Hispanic, 34.8% White, 13.3% Black, 0.9% Asian, 0.4% American Indian, and 0.1% Pacific Islander (Elrichson, 2013).

Regarding the school's academic performance, although it outperformed 44% of schools with comparable demographics, according to the New Jersey School Performance Report, City High School "significantly lags in comparison to schools across the state" (Elrichson, 2013, p. 1). Outcomes of the New Jersey High School Proficiency Assessment (HSPA) indicated that 76.1% of students were proficient in language arts and 69.4% were proficient in mathematics. The only statewide assessment in science was the New Jersey Biology Competency Test (NJBCT), where 32% of students scored proficient or higher (Elrichson, 2013). Aside from Advanced Placement testing, the NJBCT is currently the only science assessment students are taking across the state.

**Participants**

After first obtaining approval from the school principal, all 16 members of the science department at City High School were asked to volunteer as participants in the study. At a department meeting, I first made mention of the study and followed up with an email formally requesting volunteers for the study. Of the six teachers who volunteered, three were female and three were male, all of whom are described under a pseudonym to ensure confidentiality. Although not intentional, the six participants all had under three years of experience and became teachers through a teaching residency program. A summary of the profiles of each participant can be found in Table 3.2.

Table 3.2
*Participant Profiles*

| Participant | Ethnicity | Teaching experience (years) | Teaching subject |
|---|---|---|---|
| Demetri | American | 3 | Chemistry |
| Fabio | German | 2 | Physics & environmental science |
| Gabriella | German American | 1 | Biology & forensic science |
| Joshua | Cuban American | 2 | Environmental & earth science |
| Lola | American | 2 | Biology, chemistry, & environmental science |
| Sasha | Haitian/Cuban | 3 | Biology |

At the time of the study, Demetri was completing his third year at City High School as a certified chemistry teacher. He identified himself as White and held a master's degree in education. Demetri was a dedicated teacher who stayed after school to offer students tutoring and ran the guitar club. Although he was raised in a home where it was expected for him to get a college education, he contributed this belief to the White middle class experience he and his sibling had growing up.

Fabio was a second year physics and environmental science teacher. His experience in education began at City High School as a biology teacher, and he obtained his certification to teach physics after his first year teaching. He had 2 years of experience in mentoring the robotics team and also stayed late and came to school early to prepare his lessons and support students though tutoring and mentoring. He identified himself as Caucasian with German ancestry. Although his family had been in the United States for three generations, Fabio felt that his immigrant roots helped to shape his educational experiences to one that supported the notion that success comes through hard work and education.

Gabriella was in the middle of her first year at the start of the study as a special needs biology teacher. Although she was a novice teacher with little experience in the classroom, her highly effective ratings set her aside from other first year teachers in the school. Gabriella associated herself as Caucasian, but often referred to her background as being German American. She believed that her upbringing as it related to succeeding in school was unrelated to her German ancestry but rather her parents' ability to instill curiosity for learning throughout her childhood. She often referred to how her parents raised her through an inquiry based lens by encouraging her and supporting her natural childhood inquisitiveness.

Joshua, a second year environmental and earth science teacher at City High School for 2 years was eager to participate. He was the first person to reply to my email request and immediately inquired about the details of the study. Joshua's involvement in the school set him apart from many of his colleagues. He was a cofounder of the environmental science club and had worked diligently with the club's members to improve the school grounds and establish a community garden within the school. Joshua identified himself as a Cuban American. His parents immigrated to the United States shortly after their marriage and according to Joshua, instilled the importance of education early on in his life.

Lola was a second year teacher of special needs biology and general education environmental science at the time of the study and held a master's degree in education. During her first year of teaching, she was at another similar comprehensive high school in the same district but was transferred to City High School prior to the start of the 2013-2014 school year. She identified herself as White with an ancestral history of Eastern European.

Finally, Sasha was a Black woman of Cuban and Haitian decent and had been teaching biology and forensic science for 3 years, all at City High School. She holds two master's degrees, one in dental studies and one in education. During the time of the study, she was teaching only biology, environmental science, and one class outside of her certification, chemistry.

## Data Collection

Data was collected in three phases. *Phase I* entailed a semistructured interview with each teacher individually, the completion of a survey, and observations of a science lesson. Data collection for *Phase I* took place in February because it was expected that the students and teachers had fully acclimated to the school year by this point. Using the border crossing framework, it was important for the teachers and students to already be accustomed to the cultural practical norms in their classroom and for the teacher and students to be acquainted.

During the *Phase II*, teachers met with me for three sessions where they learned about and discussed readings regarding the culture of science and cultural border crossing into the culture of science. During the final session of *Phase II* the potential methods to facilitate border crossing in the science classroom were discussed. The three sessions during *Phase II* took place during school hours over three consecutive days in March.

Finally, *Phase III* consisted of a second semistructured interview, survey, and observations of each teacher teaching a science lesson. This phase of data collection took place at the end of April and early May to provide teachers the ability to reflect on the learning sessions and apply their new understandings in their teaching practices. The aim was to complete data collection prior to state testing in science that took place in the third week of May. During the late part of May and June, students were taking state assessments and final exams at which point instruction was frequently interrupted and lesson fluidity was lost. It was for this reason that data collection ended in the middle of May. The timeline for the data collection is presented in Figure 3.2.

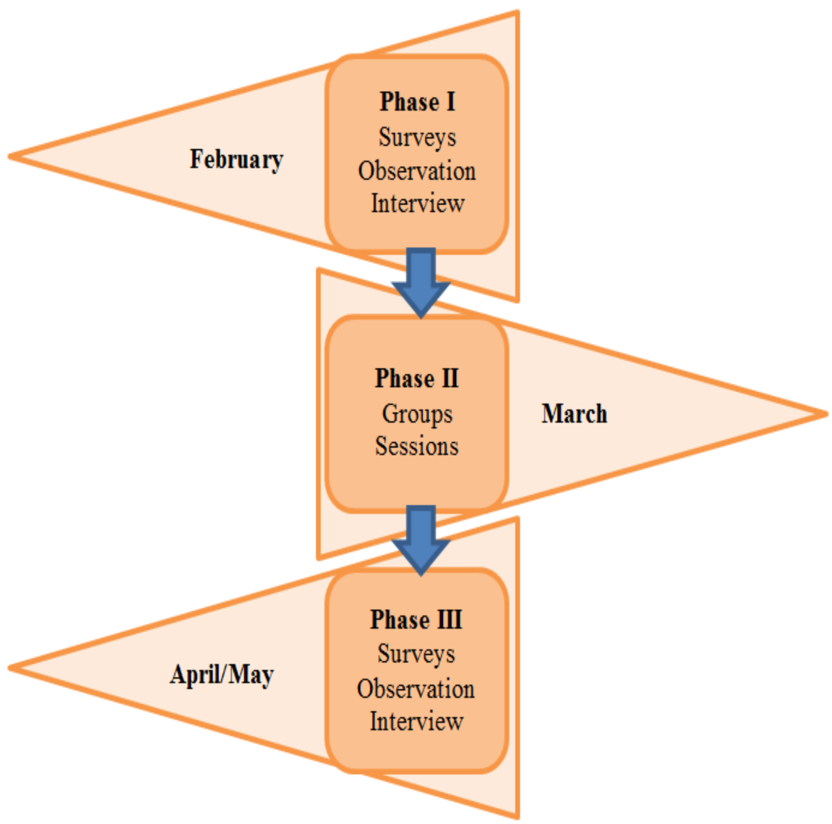


*Figure 3.2.* Timeline of *Phases I* through *III* of data collection.

## Details of Data Collection

**Phase I: Determining teachers' perspectives and classroom culture.** Data for *Phase I* aimed to address Research Question 1(What perspectives do urban secondary science teachers have regarding the culture of science and cultural border crossing and their role in science education?). Pajares (1992) suggested that the teaching methods used by teachers are often determined by their own teaching beliefs, identities, and attitudes. Several subsequent studies have supported the notion that requesting teachers to be reflective of their own life experiences, beliefs, and attitudes is essential for facilitating cultural border crossing (Atwater, 1996b; McAllister & Irvine, 2000; Scott, 1995). Using the notion of reflection, *Phase I* of the study asked teachers to first be introspective about their own cultures and beliefs as well as their own experiences in learning science in an individual interview and completing a survey. Additionally, this phase determined what perspectives urban secondary science teachers had regarding the culture of science and cultural border crossing and the role these concepts play in science education (Research Question 1).

*Phase I* of the study began with each of the participants receiving an electronic and hard copy of the *Phase I* survey (see Appendix A). They had one week, until February 5, to complete the survey and return it to me. During this time, I began the classroom observations for each teacher. I completed observations during the last week of February, at which point I began the individual semistructured interviews with each participant. *Phase I* concluded on Friday, February 28, 2014.

***Survey.*** The study began first with the implementation of a survey (see Appendix A). The intention of the survey was to obtain an understanding of the teachers' perspectives, beliefs, and thoughts on the culture of science and border crossing. In addition, the survey's aim was to identify if the teachers had a proposed method to facilitate border crossing. It was used as the first source of data to allow me as the researcher to follow up on specific responses during the interview. The first seven questions of the survey were open-ended and aligned with the questions asked during the interview. The intention of these open-ended questions was to provide the teachers with an opportunity of responding to the questions in written form and provide me with a framework from which to work off during the semistructured interview.

The last six questions were attitude scales developed by Likert (1932) to support Research Questions 1 and 3. Likert items 1, 2, and 5 on the *Phase I* and *Phase III* surveys were judgment and evaluative questions, and items 3 and 6 assessed the participants' sentiments and attitudes pertaining to science culture and cultural border crossing. Likert item 4 aimed to identify the teachers' perspectives regarding the frequency with which students cross cultural borders in science. The teachers were provided with the surveys in both hard copy and electronic form. Although most of the teachers completed their surveys electronically, two chose to use the hard copy of the survey.

***Observations.*** The second source of data in *Phase I* of this study was descriptions of the culture of the classroom and practices each teacher used. These observations occurred twice during *Phase I* for each teacher and twice again in *Phase III* for each teacher. City High School follows an alternating A/B-day block schedule, and each of the observations were conducted over complete 80-minute blocks. Each particular course that was observed was selected based on teacher and researcher availability, which made the selection process somewhat random. To reduce additional variables, the participants were observed teaching the same groups of students throughout the entirety of the study. For example, for each of Joshua's classroom observations, I observed Joshua teaching the same group of students for both his *Phase I* observations and his

*Phase III* observations. The respective courses and class sizes therefore remained constant throughout the study, and descriptive information about the classes is presented in Table 3.3.

Table 3.3

*Descriptive Data About the Classes Observed in This Study*

| Participant | Course | Block | Students enrolled | Grade |
|---|---|---|---|---|
| Demetri | Chemistry | 2B | 27 | 11 |
| Fabio | Environmental science | 2A | 24 | 9 |
| Gabriella | Special needs forensic science | 4B | 14 | 12 |
| Joshua | Environmental science | 3B | 25 | 9 |
| Lola | Environmental science | 4B | 19 | 9 |
| Sasha | Biology | 3B | 24 | 10 |

The intention of the observations was to describe the classroom environment and teaching practices using Merriam's (2009) suggestion of "rich thick descriptions" (p. 229) to support validity and reliability. An observation protocol (see Appendix B) was developed and modeled from Creswell's (2007) recommendations that primarily focused on taking descriptive and reflective notes that helped to explain the physical setting, the participants, the activities and interactions, conversations, subtle factors, and my own behavior as advised by Merriam through a border crossing lens. This required me to use Aikenhead and Jegede's (1999) approach to identifying successful border crossers by observing students' flexibility, playfulness, and/or feelings of ease.

***Interviews.*** As mentioned by Creswell (2007) and Merriam (2009), interviews were a primary source of data collection in an ethnographic study. The one-on-one interviews followed the protocol recommended by Creswell (2007, p. 136; see Appendix C). I conducted a semistructured interview with each teacher individually after school in an unused classroom at City High School. The interviews were conducted after the classroom observation and survey were completed to provide me with the opportunity to follow up on any inquiries, discrepancies, or unclear information obtained from the prior two data sources. The site and time of the interviews were selected based on their convenience for the participants and myself. Each interview was audiotaped using an iPhone 5 recorder as the primary mechanism and a backup recording was made with a handheld digital voice recorder. Once completed, each interview was transcribed. During the interview, I, the researcher and interviewer, stayed focused on the guiding questions of the interview protocol but used follow-up and supplemental questions as needed to obtain a more in-depth understanding of the participants' perspectives and thoughts. I also asked follow-up questions as needed based on the survey and observation data. I took notes during the interview protocol to supplement the audio recordings.

**Phase II**: **Informal professional learning community sessions.** The data obtained from *Phase II* were used to answer Research Question 2 (How do urban secondary science teachers respond to learning and discussing the notion that science is a subculture that their students must learn to border cross?). The primary purpose of this phase of data collection was to provide teachers with the opportunity to read and discuss primary articles relating to the culture of science and cultural border crossing (Sessions 1 and 2) as well as to develop potential teaching practices that facilitate border crossing in their science classrooms (Session 3) through an informal PLC. Table 3.4 summarizes the topics and the readings for each session. The complete list of readings and discussion points for each session can be found in Appendix D.

Table 3.4

*Summary of Sessions 1 and 2 Topics and Corresponding Readings.*

| Session | Topic | Readings |
|---|---|---|
| 1 | The culture of science | • Costa, V. B. (1995). When science is "another world": Relationships between worlds of family, friends, school, and science. *Science Education*, *79,* 313-333.<br>• Meyer, X., & Crawford, B. A. (2011). Teaching science as a cultural way of knowing: Merging authentic inquiry, nature of science, and multicultural strategies. *Cultural Studies of Science Education*, *6*(3), 525-547.<br>• Taconis, R., & Kessels, U. (2009). How choosing science depends on students' individual fit to "science culture." *International Journal of Science Education*, *31*(8), 1115-1132. |
| 2 | Border crossing and science teaching | • Aikenhead, G. S. (2001). Students' ease in crossing cultural borders into school science. *Science Education*, *85*, 180-188.<br>• Aikenhead, G. S., & Jegede, O. J. (1999). Cross-Cultural science education A cognitive explanation of a cultural phenomenon. *Journal of Research in Science Teaching*, *36*(3), 269-287.<br>• Phelan, P., Davidson, A., & Cao, H. (1991). Students' multiple worlds: Negotiating the boundaries of family, peer, and school cultures. *Anthropology and Education Quarterly*, *22*(3), 224-250. |

Hayes Mizell (2008), Distinguished Senior Fellow of the National Staff Development Council, argued that the issue with traditional professional development is that it discourages critical thinking and lacks a constructive nature. To avoid directly explaining to the teachers the concepts of cultural border crossing in science, I decided to use an informal PLC approach in the design of *Phase II* as a means of promoting critical thinking and synthesis for teachers as they tackled these complex educational ideas.

The sessions took place over 3 days during school from March 4, 2014 to March 6, 2014. The reason these sessions took place during these consecutive 3 days was mostly for the convenience of the teachers involved as this was a state testing week. When the study was initially proposed, it was anticipated that these sessions would take place after school. However, coordinating meeting times with all six teachers after school was challenging as many of the teachers were involved in extracurricular clubs and sports. There was strong administrative support throughout the entire project and with the permission of the principal, the teachers were excused from proctoring duties to participate in sessions.

The sessions were intended to run for approximately 90 minutes. However, because of the depth and richness of the conversations and discussions that took place during the meetings, two of the three sessions went beyond the predicted 90 minutes. For instance, the duration of the second session was just under 2 hours and the third session was 2 hours and 40 minutes. Sessions began at 9 am and teachers did not have to report to their regular teaching schedule until after testing, which took place at noon, providing flexibility in the length of time allowed for the discussions.

The three sessions were audio recorded using an iPhone recorder and later transcribed. Throughout the three sessions I acted as a participant observer where I facilitated the discussions around the predetermined discussion questions. Although I focused mostly on keeping the conversation on topic and redirecting discourse to the discussion questions, I did clarify reading interpretations and cited examples from the literature throughout the sessions. During this time, I took observation notes to thoroughly describe the demeanor, presence, and reactions of the teachers since this information would not be evident in the audio recordings. Furthermore, I documented any reflective notes that arose from my own analysis while the teachers were working together.

***Session 1: Multicultural science education and the culture of science.*** The first session took place on March 4, 2014 and ran for 89 minutes. Prior to the first session, the teachers were provided with electronic and hard copies of the designated articles found in Appendix D. These articles pertained to the culture of science from a multicultural lens and provided the teachers with the key literature to support the notion that there is a subculture within the science community and those specific characteristics and practices are often experienced within this subculture. Once the teachers reported to the first session, they were asked to discuss the readings, and I facilitated their discussion using the following discussion points and questions:

- Review concepts from the three articles.
- What are your thoughts on each of the articles?
- Do you agree with the authors' perspectives of science culture?
- As scientists, do you feel you can relate to this science culture?
- What effect does this perspective have on how you teach?
- How might this affect how students learn science?

***Session 2: Border crossing and science teaching.*** The second session took place on March 5, 2014 and lasted 100 minutes. Prior to this session, the teachers were provided with electronic and hard copies of the designated articles found in Appendix D. One of the articles pertained to the development of the concepts of cultural border crossings across cultural boundaries in school and the patterns that exist once students encounter such borders. The other two articles discussed how these concepts apply to science culture and how students respond once they encounter such borders during the teaching and learning of science. At the start of the session, teachers were asked to reflect on the concepts from each of the articles. I then provided the teacher participants with discussion questions to help frame the dialogue that took place during this session. The discussion points and questions are listed below:

- Review concepts from the three articles.
- What are your thoughts on each of the articles?
- Do you agree with the authors' ideas of cultural border crossing as it relates to school science?
- Do you believe this phenomenon exists? If so, from your experiences, which students have a harder time border crossing?
- Have you experienced issues with border crossing into school science in your own science learning?
- As an educator, what challenges, as they relate to border crossing, have you seen students encounter as they learn science?
- What implications do you think this has on science teaching and learning?

***Session 3: Practical implications.*** During the first and second sessions of *Phase II,* it became evident that teachers had begun suggesting and devising potential methods they could use in their classroom as a means of facilitating cultural border crossing. Prior to Session 3, they were asked to reflect on the ideas brought up during previous sessions and develop new ideas, if necessary, about what methods they would focus on in their classrooms over the next 7 weeks. When the teachers came to the third session, the goal was then to use their ideas and work collaboratively as they refined their proposed cultural border crossing methods. The ultimate purpose of this final meeting with the teachers was to utilize the social constructivist approach as the teacher participants worked collaboratively and cooperatively to further develop one another's proposed methods. The questions and points that were used to help guide the conversation during this session are listed below:

- Review major points from the first two sessions.
- How has learning about the concepts of science culture and cultural border crossing influenced your teaching practices?
- What are some methods or teaching practices we can implement that may help facilitate cultural border crossing?
- What might be some indicators that students are successfully border crossing?

**Phase III: Changes in perspectives and classroom culture**. The purpose of *Phase III* was to answer Research Question 3 aimed to identify how the teachers' perspectives and teaching practices changed in respect to the culture of science and border crossing. Once the three learning sessions were completed, the teachers were given approximately 7 weeks to implement, if they desired, their proposed border crossing methods within their classrooms. At the end of this 7-week period, the teachers were then given the *Phase III* survey to complete (see Appendix E). Once I received their survey I arranged with the participants a time to complete my observations. I then completed two classroom observations for each teacher to identify if there were any notable changes in their teaching practices as well as their classroom culture. Finally, I conducted a second individual semistructured interview (see Appendix F) with the teachers. Like in *Phase I*, the purpose of conducting the interviews after the observations and survey was to provide me with the opportunity to ask any follow-up or clarifying questions based on the results from the previous data sources. Although the questions were similar to those from

*Phase I* for the interviews and surveys, they differed slightly in *Phase III* to accurately support the corresponding research question. The six Likert scale questions were identical to the surveys that were given in *Phase I* and *Phase III* and were intended to identify any changes in teacher perspectives and attitudes.

## Data Analysis

Data analysis was ongoing throughout all three phases of data collection. As each new data source was completed, it was transcribed, if needed, and imported into the analysis software NVIVO, where formal analysis of each phase was done. The interviews, open-ended survey responses, and observations were read entirely through at the end of each phase of data collection to provide "a sense of the whole database" (Creswell, 2007, p. 150). Then, each source was openly coded, where "notes, comments, observation and queries" were written using the NVIVO software (Merriam, 2009, p. 178). The next step in analysis was analytical coding where like-codes were combined into categories or themes. Once these temporary themes were established, I went back and supported the themes with evidence and modified or merged themes (Merriam, 2009).

### Phase I Analysis

Data from the surveys in *Phase I* of data collection were enetered into an Excel worksheet and uploaded into NVIVO. I read through the data, identified key findings, and obtained a general understanding of the themes that were beginning to arise. This was shortly followed by the uploading and similar analysis of the observation data. Using the information from the previous data sources, I was able to complete the interview using the semistructured approach coupled with individualized questions to further analyze key components that arose during the surveys and observations. The interviews were then transcribed and uploaded into NVIVO.

Once all three data sources that corresponded with *Phase I* were uploaded into the software analysis program, I first analyzed each participant independently using data from all three sources to support Research Question 1. The three sources were coded into three significant areas: their perspective on the culture of science, their understanding of cultural border crossing, and their classroom culture and practices. Finally, the data from all of the participants were summarized for *Phase I*. To answer Research Question 1, themes that arose from the interviews, observations, and surveys from *Phase I* were triangulated to identify broader themes. Major themes that arose provided an initial understanding and descriptive picture of the participants in the study. Finally, the mean scores and standard deviations for each of the Likert items were determined and used to support the initial findings from *Phase I.*

**Phase II Analysis**

Being that the sessions took place during 3 consecutive days, the data were not transcribed and analyzed until the completion of all three sessions. At the completion of the three sessions, the audio recordings and field notes were transcribed and uploaded into NVIVO. The themes that arose from this component of the study aimed to address Research Question 2. As the teachers read and discussed topics related to the culture of science, the major themes that arose during their conversations were noted and discussed using specific evidence presented in Chapter IV. Likewise, Session 2's transcripts and notes were analyzed to determine the themes that arose while teachers discussed the cultural borders that exist in a science classroom. Finally, the methods that were used to analyze data from Session 3 differed from those used to analyze Session 2. Data from Session 3 was analyzed for each individual participant and aimed to describe what methods the teachers proposed to use to facilitate cultural border crossing in their science classrooms. In addition, this phase examined how the participants refined their ideas with their peers and what collaborative efforts they took to finalize their proposed border crossing methods.

**Phase III Analysis**

Of the three data phases, analysis of *Phase III* was the most complex. Like *Phase I,* the data from all three sources were transcribed and uploaded into NVIVO. Using this software, I was able to analyze the data using the same methods as *Phase I*. The challenge however, was comparing the results of *Phase I* to the themes and results of *Phase III* to best answer Research Question 3.

With only six participants, one cannot make the assumption of normality that is required for parametric statistical tests and although researchers have been known to use parametric and nonparametric statistics when analyzing Likert data, most often parametric statistics, specifically a *t* test, are used (Carifio & Perla, 2008; Jamieson, 2004). A properly constructed Likert survey with items based on a clear underlying dimension to be examined, and with sufficient evidence of equal intervals for the response options for the scale items, can be considered an interval scale and parametric statistical tests can be applied. De Winter and Dodou (2010) investigated the use of a *t* test or Mann-Whitney-Wilcoxon when analyzing Likert data and concluded that the *t* test was found to be superior. For this reason, a two-tailed paired *t* test analysis was used to determine if there was a significant difference in either direction between the means of like Likert item responses on the two surveys from *Phase I* and *Phase III*. For example, a two-tailed paired *t* test used the mean for Likert scale Item 1 on the *Phase I* survey and the mean for Likert scale Item 1 on the *Phase III* survey. A similar Likert analysis was successfully applied in a study by Lyublinskaya and Zhou (2008) where Likert scale items were analyzed to identify significant differences, supporting the use of this analysis method.

Once qualitative and quantitative analyses were completed, final conclusions that addressed the research questions were made using the theoretical lenses mentioned in Chapter II. These served to determine final research conclusions and implications to the field of science education and suggestions for further research.

**Validity and Reliability**

First and foremost, as the researcher in this study, I described my position and biases leading up to the study. To verify credibility, Guba and Lincoln (1989) suggested progressive subjectivity of the research. Prior to collecting data from each source at each phase, I documented and recorded my prior constructions and what my expected outcomes were from that corresponding data source. As a peer of the participants, I had the opportunity to work alongside them where we established a rapport and sense of trust. Guba and Lincoln suggested this as an important factor of prolonged engagement in a verified qualitative study. Additionally, member-checking took place continuously during data collection and analysis. This was particularly the case during the sessions and after the interviews. I restated my field notes and observations to the participants to verify that I had captured their intended voice as suggested by Guba and Lincoln.

It is critical to be able to trust research, but in order to do this, researchers must maintain worth in creating trustworthy and reliable studies. Reliability is different than validity as it "refers to the extent to which research findings can be replicated" (Merriam, 2009, p. 220). To address this issue, all the data was peer-reviewed and debriefed (Guba & Lincoln, 1989) by a Teachers College graduate student and by the dissertation committee to cross-reference the coding methods.  The peer reviewer had taken qualitative research methods and several statistics and quantitative research methods graduate courses and agreed to review my coding and analysis technique to ensure alignment.  The peer reviewer had experience in both methods of analysis and together, we had “extensive discussions” (Guba & Lincoln, 1989, p. 238) regarding the findings on various dates during the summer months of July and August of 2014.  Other strategies used to promote validity and reliability were writing rich, thick descriptions during classroom observations (*Phase I* and *Phase III*) and using a sample size with variation as the teachers represented different genders, cultures, races, and ages (Merriam, 2009).

**Limitations**

Like all studies, this study had several limitations that were considered when the final analysis and conclusions were made.  Although there was some diversity within the sample, it was a small sample of only six teachers which could have served as a limitation of the study. However, the methods and the research questions were designed in such a way to enable a much deeper analysis of a smaller sample size.  All of the participants had less than 4 years of teaching experience.  This was unintentional as the entire department was invited to participate.  As new teachers, the participants maybe more open to change but their inexperience and nascent knowledge of science education may also serve as a limitation of the study.

The location of the school was intentionally selected because of the school’s diversity regarding the student population and my insider access.  This, however, is also a limitation as the conclusions drawn from the data reflected only the teachers and students within this school. Some may argue that the 4 month time frame is limited, but as mentioned above in the methods timeline, it fell at a point in the school year most effective for studying the culture of the classroom.

It was expected that another limitation of the study would be the reluctance of teachers in understanding issues of diversity and the value in cultural studies regarding science education, as discussed by Luykx et al. (2004). Although this did not seem to have a significant impact on the findings, some of the participants initially struggled with understanding specifically the culture of science and the border it creates for students. Additionally, there were other challenges that often arose, common when working in large school districts, such as disruptions in classes, misaligned schedules, and difficulty in meeting with the busy teachers. This influenced the courses that were selected for the observations during *Phase I* and *Phase III* and limited the ability to control which content and grade level that was observed for each participant.

**Ethics and Reflexivity**

It was expected that some ethical dilemmas would arise during this study. In an attempt to prevent ethical dilemmas, I made note of Patton's (2002 as cited in Merriam, 2009) "Ethical Issues Checklist." The 10 items in this checklist and how they related to this study are described in Table 3.5.

Table 3.5

*The 10 Ethical Issues Described by Patton (2002 as cited by Merriam, 2009) as They Relate to the Current Study*

| Ethical issue | Consideration in proposed study |
| --- | --- |
| Explaining purpose of inquiry and methods to be used | Prior to each phase of data collection, the participants were reminded of the purpose of the study. |
| Promises and reciprocity | Participants were reminded that participation was voluntary and that no compensation was being offered. |
| Risk assessment | Literature supports the value of facilitating border crossing in the science classroom. |
| Informed consent | All participants completed the Teachers |

| | |
|---|---|
| | College IRB Informed Consent form. |
| Data access and ownership | Aside from the researcher, the peer reviewer for member checks and the dissertation committee members had access to the data and interpretations. |
| Interviewer mental health | The research interviewer had no history of mental health concerns. |
| Advice | Support during this study came from the committee members and department faculty at Teachers College. |
| Data collection boundaries | Data were only collected in the methods listed above and only under the assumption that participation was voluntary. |
| Ethical versus legal conduct | I had a legal obligation as a teacher in the school to report any misconduct that may put any of the school children at physical or emotional risk. |

Additionally, I brought to the study a set of biases and perspectives based on my involvement as a high school science teacher. As an urban science teacher, I had witnessed students struggle in crossing cultural borders from their own cultures into the culture of science. Having witnessed these challenges, I approached this study from a strong advocacy perspective. This may have influenced my efforts to provide teachers with the understanding and information necessary to support them in becoming better facilitators in their own classrooms. This perspective potentially impacted my work by persuading the teachers' views and opinions, especially as a participant observer of the study. Although I was transparent to the participants about my eagerness and excitement about the concepts that were discussed, I also informed them that they were entitled and free to have their own opinions and thoughts.

# CHAPTER IV

# FINDINGS

An in-depth analysis of each of the data collection phases and their related research questions are provided in this chapter. The findings from *Phase I* are discussed as they align to Research Question 1: What perspectives do urban secondary science teachers have regarding the culture of science and cultural border crossing and the role of these concepts in science education? Within the *Phase I* findings, results are described independently for each participant. For every teacher, I first discuss their background, teaching experience, and science history. Then, I describe the results of their survey, observations, and finally, their interview. Lastly, analyses of the quantitative data results from the Likert items are presented. At the end of *Phase I*, I synthesize the quantitative and qualitative findings for all participants and summarize it in the Summary of Findings for *Phase I*.

*Phase II* aimed to answer Research Question 2: How do urban secondary science teachers respond to learning and discussing the notion that science is a subculture and that students must learn to border cross? The organization of *Phase II* findings differ from that of *Phase I* in that each session was analyzed independently to identify established themes. A summary of all themes from each of the learning community meetings is provided following the *Phase II* findings. Finally, Research Question 3 findings are discussed. This section is organized in the same format as Research Question 1 except it answers Research Question 3: How does awareness and understanding of science culture and cultural border crossing influence the urban secondary science teachers' perspectives regarding the culture of science and cultural border crossing and their role in science education and teaching practices and classroom culture?

## Phase I: Research Question 1

*What perspectives do urban secondary science teachers have regarding the culture of science and cultural border crossing and the role of these concepts in science education?*

### Demetri

Having grown up in a White middle-class family, Demetri recalled the challenges he faced as a student, specifically in his science classes. His early views of science signified the disconnect that existed between his own interests and learning science. He stated, "It seemed like there was a large emphasis on memorization and reading . . . so I didn't find much interest in it" (Demetri, *Phase I,* Interview). This especially was the case when reflecting back to his high school experiences in science where he recalled, "I remember doing a few experiments but didn't remember the purpose for them" (Demetri, *Phase I,* Interview).

**Culture of science.** During his interview, Demetri shared an interesting perspective on the culture of science that varied from his initial survey response. He viewed science culture as one that is ever changing and open-minded. His opinion on the culture of science was that of shared ideas among the scientific community that led to constant transformation of ideas and thinking of science content and beliefs. He stated in his interview:

> Now, I feel like the culture of science is very much open-minded. There are aspects of it where it might not seem open-minded because the consensus is so strong on some of the ideas, but most of those ideas are founded in scientific data. I mean, you have to be informed enough to look at the data yourself and see if it's legitimate, but if you do see it's legitimate, I think science allows an open discussion where everybody's ideas are valued if you can support it. If you can't support your ideas, I don't think people with scientific backgrounds are going to take you seriously. [This] could be a problem for

> people with good ideas but are just unable to form a structure to support it so that might take away from some of the creativity and the ideas. But for the most part, it's a good system in the sense that everyone can have an opinion if they know what they're doing. . . I think of a change in thinking, a change in belief. I tend to think of, like the beginning of modern science, the end of the rule of religion. (Demetri, *Phase I,* Interview)

During his survey response, Demetri supported this by identifying science culture as "democratic, logical, tough but fair," (Demetri, *Phase I,* Survey). However, he added that science culture is impersonal, contradicting his initial statements during his interview of science being about open-mindedness and sharing of ideas. He believed that his students also faced this impersonal detachment to science especially as it pertains to the advanced content teachers are often asked to teach. He wrote, "I need to evaluate what I am teaching and see if it's really worth teaching in the sense that maybe it doesn't have any value outside academics, or outside of a higher institution. So, when the students [question what they are studying], sometimes it's because they're afraid of what they're learning or what they are about to learn," (Demetri, *Phase I,* Survey). Demetri believed that students have a fear of science that stems from some negative science experience and can lead to detachment and wondering about the applicably and relevance of learning science.

**Border crossing.** Demetri defined border crossing as "experiencing other cultures directly when your own personal identity and norms may be challenged" (Demetri, *Phase I,* Interview). However, when asked to apply this concept to the teaching and learning of science, he compared it to the traditional school of thought where it is OK to be wrong as long as it is logical, like in an English class. He reported that oftentimes in science classrooms, beliefs are not encouraged but rather memorized facts are rewarded and that this serves as a border between students' individuality and science learning. He proposed making science class more accepting of original ideas and building student confidence as a means of helping students cross these borders. Additionally, he suggested helping students "create a new cultural identity that establishes different norms" (Demetri, *Phase I,* Survey).

**Classroom culture.** It was clear from the beginning that Demetri's students had a good time in their chemistry class. The laughter coming from within the classroom could be heard all the way down the hallway when I observed Demetri teaching. Although the conversation was often off topic and not centered on science, students were engaged with each other, the teacher, and the class environment. The classroom culture was welcoming and comfortable. Immediately, students asked who I was and what I was doing and included me in parts of their discussions. If necessary, students walked around freely but in a respectful manner. For example, if a student had to throw away a piece of trash, there was no need to raise his/her hand, but he/she would quietly walk to the garbage and return to his seat. While Demetri taught his lessons, it was not uncommon to have half of the class standing at their lab tables engaging in conversation. There was a strong sense of community within Demetri's class as students were welcoming to one another's ideas and thoughts, whether content related or not. I defined the sense of community as a class working together toward a common goal in a respectful and interdependent manner. I also witnessed an obvious sense of ease between the students and the teacher. However, these feelings changed after students encountered new content or were challenged by the material being taught.

During my observations of Demetri teaching during *Phase I,* I noted evidence of border crossing because of the strong sense of flexibility and playfulness. However, these crossings were most evident when students were discussing matters unrelated to science, supporting the notion that students were crossing cultural barriers between one another but not with science culture. When they encountered scientific content in their assignments or class discussions, students shut down and became frustrated. Slightly irritated, one student yelled across the room during my first observation and said, “We never have time [to] finish anything!” (Demetri, *Phase I* Observation, February 25, 2014). On the other hand, I also often witnessed joking and laughter throughout the lessons and was most often related to nonscientific topics. Although Demetri offered students a variety of methods to complete assignments and worked democratically with them in refining assignments, there remained a disconnect between the characteristics of border crossing and science content. For example, while students quickly participated in discussion with Demetri about a TV show that was off-topic, they went silent and showed signs of frustration when he asked, “Alright, let’s talk about how we can dilute things, how can we dilute hydrochloric acid?” (Demetri, *Phase I* Observation, February 25, 2014).

**Fabio**

As a second generation German-American, Fabio credited his upbringing with his parents’ encouragement of his exploration of his natural surroundings as the primary reason why he always loved science. He recalled his parents consistently pushing his inquiries whenever he had a question relating to science and guiding his learning process in an organic fashion. He recalled:

> If I had a question like, “Why does sea glass get smooth?” my parents wouldn’t just give me the answer. They would ask me something like, “Well, how would you get a regular glass piece smooth?” Eventually, I would work my way to an answer alone which only furthered my interest.” (Fabio, *Phase I* Interview)

It was this continued inquiry and engagement during his childhood that made science fun and interesting and helped him remain interested throughout high school science, "even though I didn't have the best teachers" (Fabio, *Phase I* Interview). He remembered that his teachers often did not do much that was outside the school textbook:

> The only classes that got to do any labs or anything were the AP classes, and it was super competitive and inaccessible. It made it seem very much like math or anything else that it seemed like, 'here, memorize this list of stuff and you'll be tested' and moving on. (Fabio, *Phase I* Interview)

**Culture of science.** To Fabio, the culture of science was one that was inaccessible and only a field for the elite and prestigious. He mentioned in both his interview and survey that it takes many hard years of practice to become a scientist and that the culture of science is a "gated community of doctors and scientists" (Fabio, *Phase I* Survey). The culture of science for his students is therefore a daunting subject to pursue. In his interview, Fabio stated:

> I think they view it as inaccessible, that it's something hard and to be feared, and it's boring, and does not apply to them in any way. And that's not all of them, that's a large percentage [who] feel that way. That it's one thing that does not relate to their lives, and it's kind of irrelevant. (Fabio, *Phase I* Interview)

Additionally, Fabio said that his students view science as only for the smartest and most intelligent of their peers. He believed this makes science immediately a subject that is often disregarded as a potential field by students if they aren't enrolled in the honors or advanced classes. He discussed this during his interview by saying:

> Right off the bat they have this preconception that, "I'm not an honor student, I can't do this" or "Science is hard, I don't even like it," versus "I find this topic interesting, I want

to learn more about it." They think it's more, you either have it or you don't type of thing. (Fabio, *Phase I* Interview)

**Border crossing.** Like Demetri, Fabio also thought of cultural border crossing as it related only to students' own cultures. Meaning, students only had to cross borders into one another's different cultures and not into the culture of science. When asked to describe what cultural border crossing was in his survey, Fabio wrote, "When people can learn and share from each other by relating to their common differences or similarities of culture" (Fabio, *Phase I* Survey). Many of Fabio's responses to border crossing in the science classroom took a multicultural education perspective that learning in the classroom must be relevant to the students' own cultures and that teachers must make "cultural connections to their students" and "make lessons more relevant to their [students'] background . . . and prior experiences" (Fabio, *Phase I* Survey).

**Classroom culture**. During my observations of Fabio's ninth grade environmental science class, it was evident that he was using his parents' approach to learning science as he firmly stuck to the inquiry-based approach and did not provide students with direct answers and responses to their questions. In both of the lessons observed, short YouTube videos were used to help engage the students. While each video played, Fabio made sure he paused the video multiple times and asked students questions as well as had students develop and ask scientific questions. This approach of using a visual to demonstrate content and having students pose and answer questions kept this freshman class, traditionally one of the more challenging age groups within a high school, highly engaged. As the lessons continued, I witnessed a sense of mutual respect between the teacher and the students, and if students were out of line or misbehaving, Fabio was quick to make use of management skills like carrying around a clipboard to write down notes on student behavior, asking students to write their names on the board, and refocusing disruptive students.  In both observations, it was evident that during individual and group work on worksheets and textbook reading, the sense of ease and playfulness that was witnessed during videos changed to frustration and withdrawal.  Students were off-task, distracted one another, and made comments like, "Mr. K, I don't get this" and "Why do we have to do this, can't we watch more movies?" (Fabio, *Phase I* Observation, February 25, 2014).

**Gabriella**

Gabriella identified herself as a White, European American with ancestry tracing back to six different European countries.  She recalled that growing up she was unaware of the privileged world she experienced as a White woman.  After changing careers to become an urban educator and through her graduate work and professional development workshops, she had since learned about "White privilege" and how it played a role in her life.  She went on to explain how she benefited from having grown up in a White, middle-class family and how it afforded her the ability to pursue her career dreams, purchase a condo, and succeed in school.   She stated:

> So just my whole life situation was set up for me in a nice way so that I again continued with the careers I loved and this allowed me to switch careers last year from a different setting to education, and that's when I really learned about White privilege and the institutional racism that's been going on.  And so because of certain things that have been in place for hundreds of years in this country, my family, my parents, their parents, their parents before them all—that's how my life has been set up for me.  It's because of the advantages that they had, that other people didn't have, that made my life so much easier. (Gabriella, *Phase I* Interview)

Although Gabriella wrote how it was this “[W]hiteness” (Gabriella, *Phase I* Survey) and her socioeconomic class that allowed her to access a great deal academically, she still felt as though she always had a tendency toward the sciences.  She liked exploring organisms found on the beach, leading science workshops at camp, and working with animals.  Her interests continued into high school and college when she enrolled in AP biology courses where she succeeded but later encountered some trouble in chemistry class.  She attributed her challenges in her high school chemistry class to the college professor who taught the course at a very high level causing her to become disengaged and unmotivated in learning the content.  This was difficult for Gabriella because she traditionally had done well in her science classes throughout high school.

**Culture of science.**  When asked to discuss the culture of science, Gabriella referred to it as “White, middle-aged men with glasses” (Gabriella, *Phase I* Interview).  Although she was aware that this common perception of scientists was shared by many and that she, as a scientist, did not fit this description, she still pictured a White male in a lab coat when she thought of a scientist.  In her survey, Gabriella identified the culture of science as “being smart, educated and nerdy” (Gabriella, *Phase I* Survey).  It is this perspective that she said influenced her students’ view of the culture of science as being difficult and requiring extra hard work to succeed in.

**Border crossing.**  During the survey component of *Phase I,* Gabriella described how she thought cultural border crossing was about applying one’s own cultural understandings in trying to learn of another culture.  She wrote in her survey, “Learning my culture to meet someone else in their culture, seeing something from their cultural perspective” (Gabriella, *Phase I* Survey).  She then tied this into her students’ experiences in crossing cultural borders in the science classroom in that not every student has the same life experiences.  To Gabriella, crossing cultural borders meant only crossing the borders of one's own culture into those of another person's culture. When she was asked what methods may work to facilitate such border crossing, Gabriella proposed allowing students to share their ideas, beliefs, and experiences, including her own.

**Classroom culture.** During my observations of Gabriella's special needs forensic science class, it was evident from the moment I walked in that there was a strong sense of community between the students and teacher. The words, "equality," "trust," "safety," "respect," "responsibility," and "ownership" were written by Gabriella in large letters above the board and reflected what I saw in Gabriella's classroom. Her calm and warm nature invited the students to open up, participate, and play a role in the class. During one lesson, students were investigating ways to identify the different types of fibers found at crime scenes. All of the students were able to work as a class while Gabriella walked them through the techniques of fiber identification. Her teaching methods centered on guiding student inquiry through questioning. For example, while guiding the students through a forensic science technique she asked students to observe a picture and asked, "So let us talk about hair, what can we tell from the root of a hair?" (Gabriella, *Phase I* Observation, February 21, 2014). There were no set procedures or steps that the students used as they investigated. Instead, Gabriella would ask questions like, "So you said we could look at it under a microscope. . . . If we do that what could we look for as differences between the fibers?" (Gabriella, *Phase I* Observation, February, 21, 2014). One student then said, "Well let's find out what the different fibers look like under microscope first then compare it to what we research" (Student, *Phase I* Observation, February 21, 2014). Similar methods were used in another lesson where students were using fire to investigate how the different fibers burn and drawing conclusions. During both observations, students were mostly very quiet and respectful with few moments of joking and playfulness between the students and with Gabriella.

**Joshua**

As a first-generation Cuban-American, Joshua grew up associating with other Hispanic children in school, even though he only spoke English. After his older brother went to ESL classes, his family stopped speaking Spanish at home. This put Joshua in a difficult position at school because he was not identified by his White peers as White, nor by his Hispanic peers as Hispanic. He stated that he was "just always in the middle" (Joshua, *Phase I* Interview).

In the classroom, however, Joshua felt as though science was where he fit in and it was evident to his whole family growing up. He believed that his parents instilled in him the "importance of getting an education, and they both worked hard to support us during that time" (Joshua, *Phase I* Survey). This was especially the case when he became the only family member who enjoyed science. He recalled:

> I think I just ended up getting involved in science, and then I got—in my family you get pegged to something so that's what you are for the rest of your life. So I became the person that was interested in science. That kind of stuck with me. I never really thought about that, actually. I would learn a lot about the computers, I would always be helping out with something related to technology, or science. I guess that's what it was like. (Joshua, *Phase I* Interview)

And so while his other brothers were getting labeled within the family as "the athlete," or "the dancer," Joshua was labeled as "the scientist" of the family. This recognition jump started and continued his interest in science. During his high school years, Joshua was very involved in science clubs because of the interesting material and the labs and experiments they came with. However, it was biology that first challenged him in a way he had never been challenged before in his other courses.  He acknowledged that this course was difficult but worth the challenge:

> But biology I think was the first course where the amount of contents started challenging me as opposed to some of the other courses.  We just do cool stuff, like, I never dissected anything before, or I have never done any of these cool experiments.  This is like a big jump from I remember doing stuff in middle school and it was like little stuff but, to in high school like actually doing more similar-to-real experiments.  It was a lot of fun. . . . I had a teacher who was very caring.  We had to do a stem cell project. (Joshua, *Phase* I Interview)

**Culture of science.**  Joshua's thoughts on the culture of science centered around the constant questioning and investigating that scientists do on a regular basis.  He explained:

> I think, like asking questions and trying to legitimately find answers and look for information.  If you need to do an experiment to do an experiment, I think it's a lot of being curious.  Trying to do something with information once you have it.  In a way that makes sense.  I think that's how I perceive it. (Joshua, *Phase I* Interview)

He supported this claim by also discussing how his students had this view of science culture and therefore were always asking questions that enabled him as a teacher to support their inquiries.  According to Joshua, his students were always asking questions and, in most cases, this led to further engagement.  On the other hand, Joshua felt as though science culture might have been intimidating to his students.  He said, "But I think for a lot of them, science looks scary from the outside.  Every once in a while I talk to kids and they'll just say, 'well I'm just not good at science.'  I guess in the same way that when I started biology it felt difficult at first . . . it's kind of like a way of maintaining their self-esteem.  Like, 'I'm just not good at it, so whatever'" (Joshua, *Phase I* Interview).

This intimidation factor, according to Joshua, is often used as an easy escape for students. They view science culture as not aligned with their own, and therefore use that misalignment as a means of justifying their lack of success within the course. This contributes to the students' perspectives of science as being inaccessible regardless of the students' efforts. Joshua said, "They don't think any level of extra work is going to help them, they just kind of come in and try and do their best, but they leave it there" (Joshua, *Phase I* Interview).

**Border crossing.** As with the other participants, Joshua's understanding of cultural border crossing was limited to the students' own cultures and his culture. In his interview, Joshua defined cultural border crossing as giving students the opportunity to express their own cultures and "getting to know the students inside and out of the classroom" (Joshua, *Phase I* Survey). Although he seemed to not have a clear understanding of border crossing, he was able to suggest that by providing students with the opportunity to feel comfortable in class with expressing their cultures and identities as a potential method. Another method Joshua proposed to facilitate border crossing into school science was to give students a chance to ask questions during class and respecting their responses to such questions, even if tangential.

**Classroom culture.** During the first lesson of Joshua's class that I observed, students analyzed data and drew conclusions of a lab investigation on natural selection they had completed the class before. The second lesson I observed was a class where students analyzed complex text and related the concepts to how organisms change over time. During both lessons, students primarily worked independently and in small groups as they worked through the scaffolded assignments. The smooth progression and step-by-step approach Joshua took as he guided his students through each lesson enabled the students to remain on track and engaged in the content. Being that the class was predominately comprised of bilingual Hispanic students, they often spoke and asked questions of each other and of Joshua in their native language. At times, when a student would raise his/her hand and make an insightful comment or answer Joshua's question, it was customary for the whole class to clap. I observed the following interaction:

Joshua Why is the population increasing?

Student Because they have the fit trait which made it easy to survive and pass on their genes.

Joshua Excellent! Everyone, let's give him a round of applause!" (Joshua, Phase I Observation, February, 27, 2014)

Similar situations of the students supporting one another by clapping occurred eight times over the two lessons. This sense of community and care for one another, initiated by Joshua, made the classroom culture appear supportive and encouraging. There was a clear sense of playfulness between a few students, but it was evident that other students were completing their assignments simply because it was required of them. While about two thirds of the class was enjoying their time by joking and remaining at ease, others completed their assignments with a lack of enthusiasm. One student in particular would ask Joshua several times to use his phone after he completed each section of the assignment. In other words, he would rush through each component of the assignment and then wanted to immediately disengage from the class.

**Lola**

As an adopted child of an Italian, religious family, Lola appreciated her experiences growing up and thought of herself as unique. She never viewed her adopted experience as negative and embraced it growing up and throughout her adulthood. Having been raised by a very religious family, Lola attended a Christian-Protestant school from kindergarten where everything was "taught through the lens of the Bible" (Lola, *Phase I* Interview). Although she no longer adheres to the strong beliefs that were taught to her during her childhood, she is grateful for how they shaped her "personality, value to social justice, dedication, and perseverance" (Lola, *Phase I* Survey).

Throughout her childhood and education, Lola always loved learning and practicing science. She recalled her school science experience to be one that supported the notion that miracles existed and were scientific in nature. This especially was the case when she learned about evolution. She recalled:

> We were also actually taught in science class, in biology class, how to defend creation against evolution and taught evolution in a very distorted, ignorant way. So I always had a fear of evolution, but at the same time it was like this weird battle in my head because I loved science so much. (Lola, *Phase I* Interview)

Her viewpoint, however, was truly challenged when she had to write a paper about evolution in college. Thinking she had argued against evolution extremely well, she was surprised to receive a grade of only a C. She recalled her professor writing, "The writing itself is good, but nothing is scientifically accurate" (Lola, *Phase I* Interview). It was during a meeting with this professor discussing her viewpoint on evolution that changed Lola's perspective and whole stance on religion and the relationship it had with science. For her, this was a pivotal point in her learning and life. She remembered:

> So at that point in college, I was finally like opening my eyes a little more. But everything didn't have to be so like one or the other, even though I still have moved farther away from a faith belief. At the point, at least it allowed me to then learn more about evolution without being scared that I was going against my religion. So at that

> point, it was like a breaking point where she opened my eyes to just learning. (Lola, *Phase I* Interview)

**Culture of science.** Lola's perspective on the culture of science was very different from that of the other participants in the study. To Lola, science was just like another content area, such as literature and social studies. She stated in her interview, "I just looked at it like another content area that you could be studying" (Lola, *Phase I* Interview). She related it to her high school experience where all students did well in all content areas, so when someone chose to go into a science field it was because they enjoyed it. It was only in college that Lola realized that maybe there was something significant about the science field. She reflected on her relationship with science:

> Not until recently, I didn't realize it was such a competitive area so influenced by other areas. It makes sense because it's something that's affecting, very political arenas, our economical arena. . . . Nobody took anything really that seriously [in high school]. We saw it as a means to what major you were going into at college, like possibly what career it got you into. Then in college, I was only around science people. I feel like only recently have I looked at the bigger picture. Or recently meaning like in the last three or four years. Like after college. That there is so much purpose in science. (Lola, *Phase I* Interview)

When I tried to probe deeper with my interview questions into her view of science culture, Lola stated that she believed science culture to not be "true." In both her interview and survey, she mentioned that science is heavily influenced by external societal factors such as religion, politics, and economics and not as its own culture.

She believed that her views on the culture of science were also shared by her students, in particular those who enjoyed it and did well in school. She claimed:

> Some who actually just like school might see a very similar to how I saw it, as just another content area that you might be good at or you might not be good at, or you might be interested in some of the topics be talked about. That's what I thought of it, I didn't really think it was something that existed in the world, the big picture. (Lola, *Phase I* Interview)

Lola also argued that those same influences, in particular religion, weigh heavily on the students' perspectives of the culture of science. Being that many of her students came from religious households, she believed that they too were skeptical of some aspects of science and therefore may not trust her as their teacher.

**Border crossing.** Similar to her view on the culture of science, Lola's thoughts on cultural border crossing into science culture were related to religious borders. Her thoughts reflected the notion that science could be viewed from multiple perspectives and other points of view, such as through a religious or political lens. Although she stated she did not believe there was a culture of science, Lola thought that for teachers to successfully facilitate border crossing in a science classroom, she recommended that teachers allow students to share their opinions, views, and ideas before teaching content and then allow students to engage in debates over those topics. Essentially, she thought using a debate framework to guide students in conquering new topics would be beneficial. She referred to one of the borders as being religion and said, "But ultimately if they believe that a God is . . . then they do truly not understand scientific process" (Lola, *Phase I* Interview). She then described another border as being because "other students just hate it because it's a lot of work, or too much thinking, so it's the content area that they hate" (Lola, *Phase I* Interview).

**Classroom culture.** As I observed Lola teaching her lessons, it was clear that her focus was to build her students' literacy skills. As a teacher researcher in this school community, I was aware that this was a department focus for the school year and hence a large component of many science classrooms. Although the lessons were different in structure, they both required reading sections of text and discussing each section as a large class group. It was evident in both observations that Lola had strict classroom norms and practices that created a rigid environment. Although students participated, it was usually because they were called on and not due to active engagement. The classroom culture was strictly business and nonflexible in nature. Students sat in rows and were prohibited from speaking unless called on by Lola. Although her stringent policies made for a quiet and well-behaved classroom, there was little evidence of flexibility, feelings of ease, and playfulness, reducing the sense of community as compared to the other classrooms in the study.

**Sasha**

Having grown up and attended school in a nearby urban and traditionally struggling school system, Sasha believed it was her Haitian-American parents and culture that placed a significant value on education as key to her success. For her family, "education is highly regarded as a means and definition of success" (Lola, *Phase I* Surveys). It was this notion that drove her motivation to succeed in school.

Always at the top of her class, it was not until Sasha's junior year that she considered a career in science when her physics teacher engaged Sasha with his own excitement for physics and to her, most importantly, his focus on the application of the content to real life situations and problems. From that point on she became highly interested in the science field and eventually enrolled in a predental program at a prestigious school. She recalled:

> Well, for me again, I grew up in a primarily urban district. So science wasn't as interesting for me until around my junior year. I had a really good physics teacher who kind of explained in high school-in high school which kind of made things a little bit more interesting and had me kind of think about the world of science. . . . Once I got introduced to the science world I just found myself obsessed with it. Predental route in college and I was just immersed in the science world. (Lola, *Phase I* Interview)

**Culture of science.** In both her interview and survey responses, Sasha described the culture of science to be one of highly educated individuals. She further elaborated during her interview by stating, "I think of individuals who are very knowledgeable in specific areas and I think of it as a culture of elites" (Sasha, *Phase I* Interview). Additionally, she added to this notion by describing science culture as being based in the ideologies of being a thinker and problem solver. When asked how she believed her students view science culture, she stated:

> They look of it as science already being a little hard. It's a hard subject to master, do well in. I think they think of it sometimes as being boring depending on what type of science they're learning. I think they think of it as a very difficult thing to learn and hard to do well in. (Sasha, *Phase I* Interview)

She later added that in order to be successful in science, students had to master certain fundamental skills. When applying this concept to her urban students, she argued that many of them lacked these basic abilities, such as critical thinking and problem solving skills. Since her students were not practicing these skills “in their everyday lives compared to their counterparts [non-urban students] it is harder for them to do well in science” (Sasha, *Phase I* Interview).

**Border crossing.** Sasha’s interpretation of cultural border crossing was centered on the notion that ideologies are transmitted among cultures. She believed that in order to successfully teach science to students, teachers must be able to effectively “transmit the ideologies of science culture” (Sasha, *Phase I* Survey). The suggestion she made to facilitate border crossing into school science was to “call on students’ prior knowledge or experiences related to scientific concepts” (Sasha, *Phase I* Survey). Additionally, she recommended providing students with the opportunity to engage in scientific discourse.

**Classroom culture.** Immediately evident when observing Sasha’s class was the strong relationship and connection she had with her students. Her relatability and sense of humor as she led the class through each lesson created an open and welcoming environment. A key characteristic that stood out while observing her lessons was the sense of flexibility that existed between the students and Sasha. For example, if a student was off topic by asking a question or making a comment, she would briefly entertain the student in her response and simultaneously redirect them to their work. One example of this was when Sasha held up a model of a cell:

| | |
|---|---|
| Sasha | So what are these things? [Pointing at organelles] |
| Student 1 | How much does one of those [models] cost? |
| Sasha | Only five dollars. |
| Student1 | Really, that’s cheap! |
| Sasha | No, I’m just kidding, it was actually close to a hundred dollars, (class laughs). I’ll give you this model if you can tell me what these are now? |

| | |
|---|---|
| Student 1 | Mini organs. |
| Student 2 | Organelles! |
| Sasha | Very good. (Sasha, Phase I Observation, February 25, 2014) |

Although the classroom culture was warm and inviting, the students were often frustrated with the content. Prior to a quiz, students were very obviously stressed and felt unprepared. One student commented during a 5-minute study period, "This is so hard, why do we need to take a quiz on this AP level stuff?" (Sasha, *Phase I* Observation, March 3, 2014). This was quickly followed up with similar and supporting comments from other students. Overall, based on the classes I observed, it was concluded that students felt comfortable and at ease with the teacher but not with the content.

**Phase I: Likert Item Analysis**

Range values varied for the six Likert items and were dependent on the respective items. Analysis of the mean data indicated that during *Phase I* the participants had moderate to low means (3 or below on the five-point scale) for all the items except when asked to rate their opinion of how science culture is portrayed by students. This indicated that overall, the participants had no clear bias, with a midpoint or neutral position, as discerned from the Likert survey regarding their understanding of science culture and the borders it creates as relevant in the teaching and learning of science. The mean values for the Likert items on the survey for Phase I can be found in Table 4.1.

Table 4.1

*Mean Values, Standard Deviations, and Ranges for Responses to Each of the Six Likert Items*

| Likert item | Range | Mean | *SD* |
|---|---|---|---|
| 1. How necessary is the understanding of science culture in the teaching and learning of science? | (1) Very Unnecessary<br>(5) Very Necessary | 3.0 | 0.63 |
| 2. Based on your experience, how significant is understanding science culture to the teaching and learning of science? | (1) Very insignificant<br>(5) Very significant | 2.8 | 0.98 |
| 3. Rate your opinion of how science culture is portrayed by students of diverse backgrounds. | (1) Highly negative<br>(5) Highly positive | 3.3 | 0.82 |
| 4. How frequently do you think students in your classes cross cultural borders? | (1) Monthly<br>(5) Multiple times/class | 2.5 | 0.55 |
| 5. To be successful in school science, how relevant do you think cultural border crossing is for students? | (1) Highly irrelevant<br>(5) Highly relevant | 2.8 | 0.41 |
| 6. What is your position on the following statement, "To be successful in school science, students must learn to border cross between their own cultures and the culture of science." | (1) Definitely disagree<br>(5) Definitely agree | 2.3 | 0.82 |

The mean value for item 1, (How necessary is the understanding of science culture in the teaching and learning of science?) was neutral with a 3.0 and a standard deviation of 0.63. For item 2 (Based on your experience, how significant is understanding science culture to the teaching and learning of science?) the mean value was 2.8 and the standard deviation was 0.98. The mean value for item 3, (Rate your opinion of how science culture is portrayed by students of diverse backgrounds) fell slightly above neutral with a value of 3.3 and a standard deviation of 0.82. Item 4 (How frequently do you think students in your classes cross cultural borders?) had a mean value of 2.5 and a standard deviation of 0.55. The options for this item were, monthly (1), biweekly (2), weekly (3), daily (4), and multiple times per class (5). A similar position is evidenced with the mean value for item 5 (To be successful in school science how relevant do you think cultural border crossing is?) of 2.8 and standard deviation of 0.41. Finally, the lowest mean was for item 6 (What is your position on the following statement, “To be successful in school science, students must learn to border cross between their own cultures and the culture of science”) with a mean value of 2.3 and a standard deviation of 2.3. This indicated that overall, the teachers’ perspectives were not biased in either direction regarding that the culture of science and cultural border crossing and its relationship to the teaching and learning of science, supporting the *Phase I* findings from the surveys and interviews.

**Phase I: Summary of Findings**

The purpose of this *Phase I* of data collection was to assess the participants’ perspectives of science culture and cultural border crossing and to get an understanding of their classroom culture and determine if students were crossing cultural borders as they engaged in science. Table 4.2 provides a breakdown and summary of the results from *Phase I*.

All of the participants shared a common opinion regarding science except for Lola. Like the research suggested (Lee, 2003; Lee & Buxton, 2011; Tobin et al., 2005), a common theme that arose when the teachers were asked about the culture of science was that it was one that represented high levels of intelligence, difficulty, and was often feared or appeared inaccessible to students. Across all data forms, the teachers indicated that science represented the most challenging and difficult material as compared to other content areas. They viewed science as complex and often spoke about science being represented by the best and the brightest. For example, Sasha said in her interview, “I think of highly educat[ed] individuals. I think of individuals who are very knowledgeable in specific areas” (Sasha, *Phase I* Interview). Fabio wrote, “very intelligent few. A gated community of doctors and research scientists” (Fabio, *Phase I* Survey). Further supporting this theme, Gabriella wrote “being smart, educated, and nerdy” (Gabriella, *Phase I* Survey). This theme was evidenced also in the high Likert mean value of 3.33 for item 3 (Rate your opinion of how science culture is portrayed by students of diverse backgrounds).

Lola’s experiences growing up in a high-achieving religious school may have influenced her opinion of the culture of science in a way that distinguished her from the rest of the participants. She saw no difference between the culture of science and other content areas. She said during her interview, “I just looked at it [science] like another [content area], I looked at it in general, like another area that you could be studying” (Lola, *Phase I* Interview).

When asked to describe their thoughts on the culture of science and how it applied to science, Demetri, Fabio, Gabriella, and Joshua all viewed science though a multicultural lens without considering the culture of science. They described how cultural border crossing is learning about and including students’ cultures as they teach science, but they did not identify the culture of science as being an additional cultural border to cross. For example, Fabio described cultural border crossing as, "When students share and learn from each other by relating their common differences or similarities from their culture" (Fabio, *Phase I* Interview). Joshua also provided an example of this theme when he described border crossing as important between students' cultures but did not appear to include science culture as having its own border. He wrote, "When students feel safe through expressing their own cultures and being received without judgment that is when they really begin to explore" (Joshua, *Phase I* Survey).

Lola's belief was that the borders that exist between students and science are created by societal and religious influences. She wrote, "[Science culture] is influenced by political, economic, and religious factors" (Lola, *Phase I* Survey). Finally, Sasha's perspective on the culture of science and its borders was the most accurate. She viewed crossing cultural borders into science culture as "transmitting science ideologies" (Sasha, *Phase I* Interview). Moreover, she discussed the need to use students' prior experiences in helping to facilitate the border crossing.

As I observed the teachers in their classroom settings and tried to get an understanding of their classroom cultures, I concluded that the majority of the teachers were already facilitating cultural border crossing to some degree as I saw evidence of feelings of ease, flexibility, and playfulness. Demetri, Fabio, and Sasha shared a common classroom culture. They all had open and welcoming environments where the students and teachers were engaged in playful behaviors and there was a strong sense of flexibility and ease. However, this behavior and classroom culture changed once the students were challenged to do more rigorous and content heavy work. Students' attitudes changed, and the feelings of ease, playfulness, and flexibly decreased. Lola and Joshua shared common characteristics in their classrooms in that they were highly structured environments that established low levels of flexibility. Moreover, I observed more playfulness and feelings of ease in Joshua's class than in Lola's class.

Finally, I found the most successful examples of border crossing as I observed Gabriella's class. Her inquiry based and student led approach to teaching coupled with her warm and gentle nature created a classroom environment where students were playful, at ease, and flexible as they engaged in learning the content. Table 4.2 contains a summary of each participant and the corresponding findings regarding their perspective of the culture of science, cultural border crossing in science and their classroom culture.

Table 4.2

*Summary of Findings From Phase I*

| Participant | Culture of science | Cultural border crossing in science | Classroom culture |
|---|---|---|---|
| Demetri | • Open-minded<br>• Shared ideas and collaboration<br>• Impersonal | • Experiencing other cultures | • Feelings of ease, playfulness, and flexibility except when interacting with content |
| Fabio | • Inaccessible<br>• Daunting for students and feared by students | • Between the students' culture and the teacher's culture | • Feelings of ease, playfulness, and flexibility observed only during video instruction<br>• Increase of student frustration when asked to complete other tasks not involving the video |
| Gabriella | • "White male in a lab coat"<br>• Difficult and challenging | • Between the students' cultures | • Sense of ease, flexibility, and playfulness were evident during inquiry experiences |
| Joshua | • Asking and generating questions to solve<br>• Intimidating, difficult | • Between the students' cultures and the teacher's culture | • Scaffolded and step-by-step approach, community of learners supported feelings of ease<br>• Mild playfulness and lacked flexibility |

| | | | |
|---|---|---|---|
| Lola | • Like any other content area<br>• Influenced by society | • Society and religion create borders | • Teacher centered<br>• Behavior management focused<br>• Serious, nonflexible |
| Sasha | • Highly educated individuals<br>• Problem solving | • Basic skills (not recognized as a border)<br>• Transmit science ideologies<br>• Use students' prior experiences | • Strong sense of flexibility<br>• Sense of ease and playfulness but not with content |

## Phase II: Research Question 2

*How do urban secondary science teachers respond to learning and discussing the notion that science is a subculture that their students must learn to border cross?*

### Session 1: The Culture of Science

During the first session, the teachers were asked to read three articles that discussed the culture of science and how it is generally perceived by society and students. The teachers were provided with a list of suggested discussion questions (see Appendix D). Three major themes that arose during Session 1 included the culture of science as different, the culture of science as overly complex and rote, and the culture of school science as misaligned with students' cultures. Each theme is further discussed and supported below.

**The culture of science as different.** It was evident throughout the whole session that the teachers agreed with the articles in that science is often viewed by others, including those in the science community, as elitist and a culture made up of only the best, brightest, and most intellectual. Although this was mentioned in some of the participants' interviews during *Phase I*, such as Sasha and Fabio, it was the articles they said, that truly brought the feelings and understandings that they always had about science culture forward. The teachers acknowledged that a difference exists between science culture and the cultures of other content areas. They spoke several times throughout the session about how in other content areas students are not asked to think like a scientist or respond to questions and problems in scientific ways. It was argued by Demetri that in history classes, students are asked to memorize facts and explain historical moments and in English students are encouraged to create opinions of significant literary pieces. Fabio supported this notion by stating, "Like with interpretations of literature, as long as you voiced an opinion and someone supported it, or showed that you knew it, it seemed relevant, but I feel like in science it is so data and evidence driven" (Fabio, *Phase II* Session 1).

The teachers noted that even between the science fields, cultural differences existed. They determined that there are borders even within the science fields, such as those between chemistry and biology. Gabriella and Joshua both mentioned the challenges they faced while taking college level physical science courses, more specifically chemistry. Gabriella explained that while taking high school and college chemistry she experienced a similar disconnect to the culture that her students likely encounter when they may not succeed in particular aspects of science. Gabriella discussed her experience:

> I almost didn't get my science major because of chemistry, and I have to think about that like, what's wrong, I just don't think I'm good enough for chemistry? And all of our students who don't think we are good enough or smart enough for science, and I at least know how they feel about it. (Gabriela, *Phase II* Session 1)

Sasha agreed and described how scientists in the fields of biology, earth, and environmental and marine science are often viewed by the chemists and physicists as inferior.

This practice may be carried into the schools through the different science teachers and transmitted to the students. Sasha stated, “A lot of physical scientists that I’ve met, and some even teachers, they tend to have this intellectual chip on their shoulders” (Sasha, *Phase II* Session 1).

This led to conversations between the participants about the differences in cultures that exist among the various science fields and how these understandings are sensed by society and by students. Additionally, there is an even greater disparity in teaching resources in these areas of science that is possibly perpetuated by these cultural differences. They discussed:

| | |
|---|---|
| Lola | “And we've experienced this as teachers and chemistry teachers, no offense guys, they want to hold chemistry as this much harder subject.” |
| Demetri | “You speak to most adults and they tell you the class they liked the least was probably chemistry.” |
| Fabio | “And really smart people.” |
| Demetri | “Yeah, really smart people, like doctors.” |
| Fabio | “Like, eh’ physics, oh no!” |
| Lola | “If you look at teacher resources in chemistry they suck. There is so much in bio you can Google any lesson in bio or environment science and you'll come up with a fun way to teach it.” |
| Demetri | “Yup.” |
| Lola | “Chemistry is like a man on YouTube pointing to his PowerPoint, that’s the video of chem. I have found two videos that actually are interactive about chemistry.” |

Fabio "But in the physics demos, I get some MIT prof that thinks he's bringing it down to our kids' level, and I'm like wow if I'm bored right now, my students would have been gone ten minutes ago." (*Phase II* Session 1)

The teachers also described the culture of science as a different way of thinking similar to how it was described in the article, *Teaching Science as a Cultural Way of Knowing: Merging Authentic Inquiry, Nature of Science and Multicultural Strategies* (Meyer & Crawford, 2011). They discussed that in order to be successful in science, students must know how to think like a scientist. According to the teacher participants, students are not accustomed to thinking like a scientist and when they are asked to do so in their classrooms, resistance is experienced from the students. Fabio stated:

> I agree with the article, *When Science is Another World,* where they talk about the negative attitudes and disconnect students have with science because it emphasizes problem solving and they are asked to support their ideas and make conclusion and it is very overwhelming for them because they haven't been asked to do that. . . . When they have to analyze a graph I think they shut down because they already have this negative attitude like, "this is not me, it's beyond me because I haven't been asked to do this, I haven't had practice with this," not because they can't but because they haven't practiced it. (Fabio, *Phase II* Session 1)

Joshua agreed with this statement and indicated that students are often being asked to leave their own ideas and ways of thinking outside of the classroom. He believed that in some way we are asking students to disregard their prior learning experiences, "we are assimilating them into science culture and saying that they have to abandon all previous notions that they've learned and come do science" (Joshua, *Phase II* Session 1).

The teachers also indicated that the cultural norms that are practiced in high school science classrooms are vastly different from those in the science field. Throughout the session, there were several references to the disparities that exist between what they ask students to do in the classroom as compared to what scientists do in the field. They discussed how school science differed from the science of various careers. Lola stated:

> What is funny is that this is so vastly different from the scientific community at large. The idea that teaching science in the classroom is so different from reality because once you actually do go into science, you work in the field, hands on, investigating. (Lola, *Phase II* Session 1)

Demetri supported this statement by saying, "if you want them to have a good science experience when they are doing experiments then you shouldn't expect them to have the same result. True scientists make mistakes and then need to figure out those mistakes on their own." Ultimately, the teachers agreed that the science students experience in school is very different from what traditional scientists experience in their fields, indicating that there are potentially greater borders between school science and authentic science experiences.

**The culture of science as overly complex and rote.** A second theme that arose during the first session discussion regarding the characteristics of the culture of science was its intricate and highly complicated nature. The teachers often referred to the complex vocabulary that is asked of the students. Joshua stated, "The complexity of the language is like, well you can't speak our language so forget you, but I think that continues when teachers go back to the classroom, even I did that at first" (Joshua, *Phase II* Session 1). Fabio joked after Joshua's comment, “I remember saying ‘G.I. tract’ to my students and having them look back at me in confusion. When I said digestive system, they all immediately were like ‘Ohh!’” (Fabio, *Phase II* Session 1). The teachers acknowledged that to be successful in science classes, students must learn the difficult vocabulary and terminology similar to learning a new language.

Both Demetri and Joshua referred to the articles they read while discussing the use of complex terminology within the science culture. Joshua stated:

> Well isn’t it the culture, if you give an explanation to science in a college setting using the terminology a lot you, are correct, but I remember this one time when a student in the class, he might have been from [the name of the city] or another urban center gave an explanation in less complex terms, and the other kids just looked at him, but he had the right answer . . . it’s a performance [science] and it is a culture, the idea that the way I’m supposed to talk in science, and it’s good to acknowledge, but kids are not used to using that language so sometimes they feel when they read a text and they encounter that language, that it’s inaccessible. (Joshua, *Phase II* Session 1)

Not only did the teachers discuss the nature of the complex language, but they also felt that the depth to which science is taught also played a role in why students are reluctant or fearful of science. Lola in particular was very adamant about the amount of detailed content that students are required to learn when they are enrolled in a high school science course. She argued:

> Making them know each level and step of cellular respiration and mitosis is way too much information unless you’re in college majoring in biology, I really don’t think it’s a necessity . . . we are requiring them to be a biologist in high school. (Lola, *Phase II* Session 1)

Other such comments from the group indicated that the amount of information current science curricula is asking students to learn can serve as a barrier to succeeding in science. Gabriella thought back to her first year when she learned that according to curricular standards the students “don’t need to know the cell organelles because they already learned in it middle school, and I was like blown away because I didn’t in middle school” (Gabriella, *Phase II* Session 1).

**Science culture as misaligned with students’ culture.** A final theme that arose during the first session was one where science culture was misaligned to the cultures and interests of the teachers’ students. According to the teachers, for many students science is not seen as an attractive field to go into due to the manner in which the science culture is portrayed by the media, society, and the discipline itself. Joshua stated:

> Science is not really, in terms of our society, valued while other disciplines are. The people who are cool and attractive and socially competent are the ones in other disciplines, and the scientists are intelligent and motivated but super geeky and can’t talk to people. (Joshua, *Phase II* Session 1)

This perspective on who goes into science and who makes up the science community makes it difficult for many students to pursue science. Terms and phrases like, “socially inept,” “lab coats,” “people who can’t talk to other people,” “geeks,” “unemotional” and “crazy” (*Phase II* Session 1) were all used at various points of the session to describe science and scientists. This perspective on science culture makes it difficult for students to therefore relate to the field and deters them from seeing themselves as pursuing science as a career.

In addition to the societal influences that cause students to be disinterested in science, the teachers also thought that the subject doesn't make itself appealing to most students because students have trouble relating to those who are in the field.  Joshua summarized this notion well:

> It just boils down to the fact that the early years of science and its relatability is often very low for kids.  They don't see it in their lives; they don't see how it relates.  They don't see what real scientists are and what they do. (Joshua, *Phase II* Session 1)

Gabriella shared the story of how she wanted to be an animal trainer and marine biologist, but to her, those were not true science fields. She discussed:

> I didn't want to be a lab coat scientist mixing by myself in the lab, and I kind of went into animal behavior and thought, I'm going to be an animal trainer or marine biologist, but from what I thought it was nontraditional science and a softer science then all the other things I've done in science.  I still kind of feel like, that's not real science and I think my kids feel that way too. (Gabriella, *Phase II* Session 1)

The teacher participants agreed that there was a misalignment with the culture of science and their students' cultures.  However, some discussed the successes they have had in getting students interested in science when they taught certain concepts, perhaps because students could more easily relate to these specific topics.  For example, Sasha commented, "Even with all the content in biology, the most successful sections tend to be evolution and cancer because they are more relatable, they can connect with it" (Sasha, *Phase II* Session 1).

**Session 2: Crossing Cultural Borders into Science**

During the second session, teachers discussed the cultural borders that exist in science classrooms as well as what students do once they encounter such borders and how they can be crossed to succeed in science.  Two themes arose while discussing the cultural borders that exist in science. The first was regarding the factors that create such borders and the second regarded students' reactions and actions that take place once they encounter these borders while learning science.

**Factors that create cultural borders in science education.** Similar to in Session 1, the teachers referred to the complex knowledge and terminology used in science as a primary factor that separates students from their own cultures and the culture of science. Several times through the conversation this aspect of science and the border it creates was discussed. Sasha claimed, "There are more words in science than many languages have that make up their whole language" (Sasha, *Phase II* Session 2). Demetri and Fabio viewed it as a deterring characteristic that is predominately found in science classes. Demetri described it this way:

> It is causing students to not be interested in science because of the language barrier that doesn't exist in other classes. In order to be successful in school science, students must cross this cultural border that has its own language and set of vocabulary. That is overwhelming." (Demetri, *Phase II* Session 2)

Fabio related this same concept to the complex nature of science language leading students to believe that they cannot answer a question or solve a scientific problem without using such language. He claimed that in order to be accepted by the science community one must be fluent in its language. He stated:

> You have to call it "chemosynthesis" and not just "making energy from chemicals" which is not expected in other disciplines. So there is this canyon between what their experiences are and science culture. . . . So once again science culture is glorified and you're not part of it if you can't speak our language. (Fabio, *Phase II* Session 2)

According to the teachers, borders are also created as a result of the disconnect between school science and "real" science. It was argued that what students see as science in schools is not representative of what real scientists do. Joshua thought back to when he showed a clip from the Planet Earth series and recalled how surprised the students were to find out that the people who travel the world filming such productions are also scientists. Demetri similarly explained his own experiences in the lab, "I worked as a scientist and in no way did I have to sit and memorize text and solve problems that were scripted like our students do" (Demetri, *Phase II* Session 2). The teachers concluded that the borders that exist between students and school sciences are vastly larger than those that exist between students and authentic or "real" science. Fabio described, "You can't tell me any kid doesn't love science. They play with tools, they figure things out or problem solve, they play in the dirt, they explore and interpret the world around them" (Fabio, *Phase II* Session 2). Fabio mentioned characteristics that make up science but are often absent from school science.

While discussing the borders that exist between science culture and students' own cultures, the teacher participants acknowledged that when working with urban populations there are often additional borders that stand in the way of their students' success in science. They argued that the basic skills of their students were often so low that when they tried to teach more complex science topics or do scientific investigations, students' inability to read, write, and do basic math established a border that in turn made science less accessible for their students. At one point, the group debated whether proficiency in these basic skills was essential for success in science:

Lola — This is through the eyes of an urban context and it's not just science in general.

Fabio I think the issues are still the same.

Lola It's not. That's the gap of basic skills.

Fabio I think that's a difference in performance but not of them not liking the culture [of science].

Lola But it's going to make you like it less, suburban students don't have that [basic skills gap] challenge.

Joshua We can't answer that question. For me to speculate what happens in a suburban classroom. What I'm saying is this, what we can talk about is our experiences in urban education. What we can comment on is what is happening in our school and our kids, and I can't look at others.

Lola But we have to know the difference between coming in with the understanding and basic skills and not coming in with that. There is a confusion between why people in general and why students in our school are even more scared of going into science. Because if they came in with those basic skills. . .

Sasha You can teach them science without those skills maybe not at our level, but they can learn it. One thing that is always surprising and a challenge, besides the basic skills, is that there are a lot of words, simple words, my students do now know. So I have to go back and teach them certain terms, like the word 'influence,' 'correspond,' 'increase,' or 'decrease.' There is a language barrier but even with students born here. So those are the challenges that I have, it's not impossible to do it, but it's a challenge for

> me and for the students, but I still try to teach them science. It can be done. (*Phase II* Session 2)

It was clear from the conversation that Sasha and Fabio shared a mutual perspective, that a lack of basic skills does not create an additional border because we as teachers can supplement students' learning to engage them in science. However, Lola argued that those basic skills are imperative in order for students to cross borders and succeed in science.

**When students encounter cultural borders while learning science.** A second theme that arose during the second session was regarding what students do once they encounter these borders in science. The participants categorized students based on the students' reactions to these borders. The first group of students is comprised of those who encounter such obstacles and succeed. These are usually those who have what the teachers called a "congruent cultural experience" (Joshua, *Phase II* Session 2). The teachers believed that these students already have a "link between being more successful at cultural border crossing because they come from a supported environment where education is highly valued" (Lola, *Phase* II Session 2). Students who can "easily assimilate into the culture of science" as Gabriella (*Phase II* Session 2) discussed are generally the ones who struggle less.

Fabio saw some of his own students in the Chinese student mentioned in Phelan, Davidson, and Cao's (1991) article, whose parents expected her to achieve academically and therefore she crossed the necessary borders. Students like her are common in the classes that the teacher participants had. Joshua pointed out that many of his students got good grades, participated, and were respectful and that they may then be perceived as having successfully border crossed when in actuality they were just good students. Demetri supported this notion by stating, "Students figure out how to get through the system without actually learning" (Demetri, *Phase II* Session 2). Gabriella agreed with these comments and followed up by saying, "the potential scientists get As in science because they are good students and they know what they need to do to succeed, but they are still not interested in science and why is that?" (Gabriella, *Phase II* Session 2).

The teachers were able to categorize their students into a second group based on their reactions to such borders. This group of students shuts down or disengages once they encounter borders between their own cultures and those of science. All of the teachers felt that a majority of the students they worked with fell into this group and that most students in urban schools could be categorized this way. The teachers reported that the degree of diversity in the students they serve and the multitude of cultures that exists in their classes make it even more challenging to facilitate students in crossing those borders. The following exchange highlights the teachers' experience:

Lola — From that we like to lump in, African American and African. It's a very different culture, same with Latin American and from a Latin speaking country. So you have students that are from Africa and their value of education and their knowledge of academia is much higher than an African American student. So it's interesting that they have the bigger culture difference but in academia it's not as big of a cross.

Sasha — I totally agree. I definitely think that in my classes, which are a mix of everybody, it's most difficult for the African American students to cross that border. I don't know if it's most difficult or if it's that they just don't want to. In some cases.

| | |
|---|---|
| Demetri | Maybe it's difficult [to border cross] because they in some ways are expected not to." |
| Lola | Like someone said, science is not storytelling and some African American culture comes from subsets of storytelling. |
| Sasha | Think about rap music, it is storytelling. |
| Joshua | With some of the Hispanic males I see the same culture dominating. I don't necessarily [think] it has to do with wanting to look cool, I think its resistance but I think even students that are African American, Hispanic or even some White, that apply the urban culture to themselves have the most trouble. So what I'm saying is that it's not limited to a single group. (*Phase II* Session 3) |

The teachers also identified younger students in their classes as disengaging once they met with these borders. They discussed how adolescents, especially high school freshmen, struggle to find their own identities, much of which is done within the school setting. Fabio argued, "Younger students are still trying to define their own cultural and personal identity, so I feel the older students are more comfortable in their cultural identity and therefore more willing to border cross" (Fabio, *Phase II* Session 2). Gabriela supported this notion and argued that it is in part due to the portrayal of science and scientists that students do not want to associate with. She claimed, "teens more than any other group of people are forming their identities, 'so what do I want to be?' They don't want to be alone and nerdy. . ." (Gabriella, *Phase II* Session 2), which is what science is to most students.

It was toward the end of this session that the teachers realized that there is a group of students who was not mentioned in any of the readings. They classified this group as the students who can cross, but do not want to cross the border into science. These are the students who are capable of succeeding in science but because of the stigma attached to the science culture (discussed during Session 1), these students opt not to cross into science. The teachers recalled:

| | |
|---|---|
| Sasha | I have students where I know they know the material, they can understand everything but they just don't want to show me. |
| Gabriella | I [the student] don't want to show you or the class I can do this. |
| Sasha | They will tell me if it's one-on-one, but they don't want to show me or the class. |
| Demetri | It goes against cool culture. |
| Sasha | I'm like, you know this. Why don't you want to do it? (*Phase II* Session 3) |

While not a theme, it is important to mention that three of the teachers began to make connections as to how they could better support their students when their students encountered these borders. It was as though the teachers viewed these borders as images to which their students must learn to overcome. Joshua mentioned the need to scaffold and make lessons relevant, Sasha discussed the use of KWL (know, want to know, learned) charts in accessing student's prior knowledge, and Gabriella included the need to discuss the scientific discoveries of scientists who are more representative of the students' gender, culture, or race during her lessons. Teachers built upon these ideas in Session 3.

**Session 3: Methods to Facilitate Border Crossing**

Prior to sessions 1 and 2 the teachers were asked to read articles pertaining to the session's topic. Although there were no readings for session 3, the teachers were asked to synthesize the information from the previous sessions and construct ideas regarding how they could apply such concepts to their teaching methods. During the early portion of session 3, the participants discussed what they had learned over the last 2 days and how this new information influenced their philosophies on teaching science. The overall consensus was that although they were aware that students were disengaged in science and that there is a distinct culture within the science community, they had not fully understood the connection between science culture and the barriers that exist for students as they attempt to cross into science. They also acknowledged that they needed to make some changes to their teaching to address the issues discussed during Sessions 1 and 2. Although the conversation often went toward the misalignment of standards and policy, some realized that there were things that could be done in the classroom to aid the process of border crossing. For example, in response to Lola's comment about changes needed in the academic system at large, Fabio replied, "It does, but it doesn't mean that we can't change things in our classrooms in the meantime" (Fabio, *Phase II* Session 3).

The primary purpose of Session 3 was to have teachers discuss and plan the methods they intended on using within the classroom to better facilitate their students' border crossing into science. The teachers came in with prepared ideas, some of which were already mentioned in the earlier sessions, on the practices they could implement in the classroom. The findings below are organized by teacher to tell the story of what they planned to implement as well as how they refined their ideas with the help of their peers.

**Demetri.** For Demetri, it was important for his students to pursue scientific interests in a debate format. He thought that by identifying ethical issues in society that related to science and structuring his class in a debate design, students would inevitably bring up questions relating to scientific content. He believed that if the teacher planned it right, by selecting appropriate questions and guiding the students while keeping their interest in the topic, they could become better engaged in science.  Demetri argued, “Maybe if they can become interested enough in the topic then all the other stuff that everyone here is focused where it has a meaning to them” (Demetri, *Phase II* Session 3).

His plan was to engage students by using the debate format in the classroom and then based on the questions and content that arose, he could “take the time to focus on the content they bring up during the class” (Demetri, *Phase II* Session 3).  Essentially, by selecting specific relevant topics, such as the use of chemical warfare and the legalization of medical marijuana, students would have a platform to raise questions and therefore guide the instruction, similar to an emergent curriculum.  He mentioned:

> I figure I can do content on content days and set aside days for like labs and debates that are directly related to the content just to generate interest in the topic about to be taught. It’s not the limitations in the curricula, it’s our comfortability to the content. (Demetri, *Phase II* Session 3)

**Fabio.** At the start of the third session, Fabio did not appear to have a clear understanding of what methods he would try to implement in his classroom.  He first thought he would focus on validating all students’ ideas, regardless of accuracy, as a means of incorporating them into the scientific community.  As the session progressed, he aimed to “introduce more and more evidence and have them refine their ideas” (Fabio, *Phase II* Session 3).  He also thought of having students become more involved in their learning by creating more problem-based projects throughout his lessons.  However, he envisioned this as a challenge because “problem-based learning is hard because of the number of students we have and classes” (Fabio, *Phase II* Session 3).  At the early part of the session, it seemed as though Fabio was struggling with narrowing down the method that he wanted to implement in his classroom.

With the help of his peers and by listening to the conversation about how others were planning to implement their methods, Fabio selected and refined his strategy. He would begin each class with a problem related to the students' lives, such as the continued decline in trout in the nearby river. By using these real life problems that students were exposed to, they could then use data, investigate problems and solutions, and draw conclusions. He planned to "make their view and cultures valued in the classroom. So what are the problems, and how can we create an explanation for this phenomenon" (Fabio, *Phase II* Session 3). Another topic he planned to use as a means of initiating interest in a new unit or chapter was to provide students with the problem of increased rates of asthma in their city. He hoped that a situation like that would stimulate interest and bring forward questions and thoughts relating to the content in the curriculum.

**Gabriella.** In Session 2, Gabriella mentioned how difficult it was for students to get engaged in science because they felt that they could not relate to science for one of two reasons. She believed the first reason was that there are not enough scientists representing minority populations. The second reason was because students' perception of a scientist was "in your lab doing research, alone" (Gabriella, *Phase II* Session 1). Gabriella used this idea to build upon the method she intended on using in the classroom to facilitate border crossing.

Gabriella decided that she would focus her instruction on the different types of scientists and careers available in science. Her purpose was to expose students to the multitude that makes up science with the hope of expanding students' perspectives beyond the typical White male in a lab coat. She explained her rationale this way:

> There is so much more out there related to science that is considered science. . . . I think they need to know that working in the field is science. Even in my one head as an

educated adult, I think I'm not a scientist. So that's what I'm going to focus on. (Gabriella, *Phase II* Session 3)

**Joshua.** Joshua advocated for increasing literacy skills in his classroom and therefore incorporated this into his method of facilitating border crossing. Like Fabio, Joshua decided to spend more time developing problems that were relevant to the students' lives in the beginning of each lesson or set of lessons to initiate their thoughts and interest in the content. He hoped he could spend more time preparing introductions to these problems that were meaningful and helped students build upon their literacy skills. Joshua felt that one border that existed between students and science is the lack of interesting reading materials, and he claimed that science is often written in a passive voice. He argued, "Science writing is so incredibly boring . . . in its passive voice, and it's not accessible and a lot of the material is not relatable" (Joshua, Phase II Session 3). He hoped that by starting the lesson with a short reading that introduced a problem in a more captivating way, students would want to solve the problem.

While he was discussing his intended method, Gabriella referred back to the prior sessions when the group discussed the culture of storytelling. She added to Joshua's comments by saying, "it could dove-tail nicely because your introduction will be a story, like a real storytelling [of the problem] and not just 'read this paragraph'" (Gabriella, *Phase II* Session 3).

Lastly, Joshua hoped to also incorporate small group work to solve real life problems. He said:

> It makes it more social and allows them to express their culture and having those group discussions in between and after evidence is presented would be really nice because it allows them to process and come up with ideas and questions together, like real scientists do. (Joshua, *Phase II* Session 3)

He expected that by providing a problem in conjunction with having students working together trying to solve that problem would "generate more interest and reduce the barrier and making it less distant" (Joshua, *Phase II* Session 3).

**Lola.** During the first two sessions, Lola was a dominant participant and added impressively to the conversation. However, during the third session, Lola had a difficult time participating as much because of her current circumstances as a teacher. She had struggled during this school year because she was teaching content she was not certified to teach (chemistry) and was teaching in multiple classrooms. She claimed the given situation prevented her from doing labs and other activities she normally would have included in her instructional practices. When it came time to share their ideas on the method they planned to implement, Lola replied with, "this whole conversation made me really depressed because my whole focus last year enabled me to do this. . . . I feel this year that I did a disservice because I hate chemistry and it just sucks, it's not cool, I'm not passionate about it" (Lola, *Phase II* Session 3).

With the help of the group, Lola was able to refer back to her experiences the year before when she successfully developed and implemented a method with good results. She suggested using this same method this year. At the start of a new topic, she wanted to give students a question related to the content. For example, "What is AIDS?" The students would then be asked to ask that same question to five people (family or friends) who were not permitted to use any other resources to help them answer the question. When students returned to class, they would generate a single comprehensive response based on the answers they received from the people they interviewed. The students would then identify any misconceptions and correctly revise their answer to the question as they learned new content. Demetri really liked this idea and supported Lola by saying, “You are kind of forcing them to merge their two worlds, at home and at school.  All these ideas together, which is great” (Demetri, *Phase II* Session 3).

**Sasha.** Although Sasha had used the KWL chart in her classroom various times, it was during Sessions 1 and 2 that she began to connect its use as a tool in facilitating cultural border crossing for science students.  Her plan therefore was to make a more concerted effort in including the KWL chart at the start of a set of lessons.  She said, “I want to continue with the KWL but make it more, I want to do more with it” (Sasha, *Phase II* Session 3).  Her plan was to use it as a permanent and living component in the classroom that was present and constantly changing throughout each lesson and unit.  When Sasha encountered the problem of not having enough wall space for each class to have its own KWL chart, Gabriella suggested saving it on the SmartBoard.

Her main purpose in using the KWL was to give students a voice.  She claimed she wanted “to show students that they have a voice and that their prior knowledge does matter and can be used and built upon” (Sasha, *Phase II* Session 3).  She hoped this would not only initially engage the students, but also keep them engaged and help them “evaluate their own misconceptions” (Sasha, *Phase II* Session 3).  Sasha believed that using the KWL chart would “help with the border crossing because the students will always see their views help shape the lesson” (Sasha, *Phase II* Session 3).

**Other themes from session 3.** While analyzing data from session 3, it became clear that there were two subthemes that arose in the conversation that are important to discuss.  The first is regarding the indicators of successful border crossing and the second being the expected challenges that arise when attempting to facilitate cultural border crossing in their science classrooms.

***Indicators of successful border crossing.*** At the close of the session, I reviewed Aikenhead and Jegede's (1999) indicators of successful border crossing: "sense of flexibility, playfulness and/or feelings of ease" (p. 274). The participants were then asked what other factors they might use to determine whether their method was a useful tool in facilitating students' border crossing. Gabriella first responded and shared an indicator that was unique to her method. She said, "I think if they start bringing up or asking, or extending their questions about scientists . . . showing more interest in science fields, especially those who aren't 'traditional science" (Gabriella, *Phase II* Session 3).

Sasha, Fabio, and Joshua all discussed how increased participation, enthusiasm, scientific questioning, and excitement for learning are key indicators of successful border crossing. While Demetri agreed, he also added that he would observe how students interacted with other students and whether they grouped themselves based on scientific interest or social preference as they tended to do.

***Expected challenges.*** While constructing their methods for facilitating border crossing, some concerns arose from the teachers regarding challenges they may face while trying to implement these ideas. The primary concern for the teachers was the inability to properly plan for such activities and methods due to pressures beyond their control. With the constraints of unit plans, the collection of student data, and observation schedules, the teachers worried they may not be able to implement their planned methods. When speaking about why the teachers' new ideas and methods were not used more often in the classroom, Joshua explained, "a lot of this is burdened down by other tasks we are doing like unit plans . . . but we need to find ways to do it without taking away from constructing good lessons" (Joshua, *Phase II* Session 3). Lola also expressed her concern about teaching content out of her certification area and having to switch between classrooms.

**Phase II: Summary of findings**

During the *Phase II* of data collection, teachers read and discussed 2 sets of three articles related to science culture and border crossing into science culture and identified potential teaching methods to help facilitate this border crossing. This second phase occurred over three sessions each averaging of about two hours in length.

It was evident that after Session 1 with the teachers they identified that the culture of science was very different from other content areas. For example, Joshua said, “I think it draws on this idea that we are assimilating them into science culture, to abandon all previous notions they’ve learned and come do science” (Joshua, *Phase II* Session 1). Joshua later supported this when he said, “Science is not really, in terms of society, not necessarily valued as other disciplines are valued” (Joshua, *Phase II* Session 1). The teachers believed that even within the science fields (e.g., chemistry and biology), there were cultural differences that in turn made it challenging for students to become successful. Often discussed was the difficulty that students and even the participants experienced in learning chemistry compared to the other sciences. Lola said, “I’m not good at chemistry, it’s not by specialty, but in high school, we make them [students] be good at chemistry” (Lola, *Phase II* Session 1). Sasha similarly said, “I almost didn’t get my science major because of chemistry . . . I just don’t think I’m good enough for chemistry . . . at least I know how they [students] feel” (Sasha, *Phase II* Session 1).

During Session 1, the teachers often discussed the characteristics that make science culture unique. They determined that even the skills, both practical and cognitive, used in science are different from those used in other content areas, which often makes the content difficult for students. For example Sasha stated, “We may ask more than other fields of them [students], like the basic skills, critical thinking, and applying knowledge” (Sasha, *Phase II* Session 1). Likewise, Demetri discusses how students become overwhelmed with how much science classes ask of students. He stated:

> . . . they don’t like it because it emphasizes calculations and mathematical problem solving. That’s another one, the problem solving. Although I think they like problem solving, the way they see science, it’s like ‘ok prove this, let’s make a conclusion on this data’, they see it varies. It’s very overwhelming for them and they haven’t been asked to do that before. Like their other classes like in math class, it is ‘this is the answer’ and in English this is the fact from the book, this is what Shakespeare said. Here are the extensive bio facts you need to memorize. (Demetri, *Phase II* Session 1)

A second theme that arose during Session 1 was that science culture requires students to learn overly complex and often unnecessarily detailed content. The teachers believed that current science culture encourages the rote memorization of detailed facts and focuses less on the science skills and practices. Sasha stated, “We might be way too focused on content knowledge in science” (Sasha, *Phase II* Session 1).

A third theme that was found in the first session was that science culture was misaligned with students’ own cultures. This in turn, was believed to make students see science as unappealing, unrelatable, and inaccessible. By the end of the first session, the teachers had essentially discussed the cultural borders that existed between students’ cultures and the culture of science without formally using the phrase, “cultural borders.” They would soon read articles on cultural borders in science in preparation for the second session.

A first theme that arose during the Session 2 centered on the causes of the existing borders, such as language differences, lack of basic skills, and misalignment between school science and authentic science. All of the teachers at some point discussed the causes of such borders. Although this was not a research question for this study, it is important to note that the teachers found it necessary to bring up the causes of such borders. For example:

> They are used to having teachers simplify things for them to make sense to them, but when they get to science there is this whole idea that it has to be more complex. For example, you have to call it "chemosynthesis" and not just "making energy from chemicals" . . . so there is this canyon between their expectations and what happens in the classroom. (Fabio, *Phase II* Session 2)

A second theme in Session 2 regarded the students' responses when they encountered such borders in science. For example, teachers grouped students into different categories based on how they responded to these borders: (a) students who successfully crossed borders, (b) students who appeared to cross but in actuality did not, and (c) students who had the potential to cross but opted not to.

During Session 3 of *Phase II*, the final session, the teachers were asked to think of ways to facilitate cultural border crossing in their classrooms. The teachers worked collaboratively to help refine one another's strategies in order to formulate a solid and organized plan of action. Demetri decided he would implement a debate format in his classroom that was less focused on chemistry content and supported common and interesting scientific topics. He hoped this would generate more interest in the scientific topics and therefore encourage students to cross the cultural borders. Fabio opted to use more significant and a relevant "do now" in an effort to capture students' engagement early on in the lesson and so they would see how the content they were learning was relevant to their own lives. Having experienced herself the disconnect between lab research science and other practical science fields, like animal training and other atypical scientific fields, Gabriella hoped to include more references to nontraditional science fields and scientists throughout her lessons. She intended to increase students' awareness of the various areas in science by exposing them to scientists who came from similar backgrounds as her students. Joshua's plan was similar to Fabio's in that he wanted to introduce his lessons with a relevant and applicable situation to first engage his students. However, his plan differed from Fabio's in that he wanted to include interesting and relevant readings as well as increase his use of group problem solving activities. Lola's plan was to engage students in student-led questioning. Her intention was that by providing students with the opportunity to ask their peers and family members questions, they would become more vested in their learning of science. Finally, Sasha wanted to focus her methods on increasing her usage of the KWL chart. She anticipated that doing so would provide students with an opportunity and forum to have ownership over their learning and therefore enable them to cross borders more easily. Overall, it is evident that most of the teachers opted to use methods that use the student's ideas and interests as relevant to the content. A summary of the participants' proposed methods and rationales is presented in Table 4.3.

Table 4.3

*Participants' Proposed Methods for Facilitating Students' Border Crossing in Science*

| Participant | Method | Rationale |
|---|---|---|
| Demetri | Scientific debates | Use stimulating and controversial scientific topics to generate interest and encourage students to explore more difficult scientific content |
| Fabio | Relevant "do nows" | Start each lesson with a "do now" that includes information or data directly relevant to the students' lives and their community and introduces them to the |

| | | |
|---|---|---|
| | | content as a means of bridging the border |
| Gabriella | Increase references to science careers and scientists (nontraditional) | Provide students with examples of science related fields that differ from lab based jobs, as well as expose students to various nontraditional scientists to make science more relatable |
| Joshua | Relevant literacy based introductions coupled with group work | Merge literacy skills by providing students with interesting and relevant science articles to introduce content<br>Mimic scientific practices by including more group problem solving |
| Lola | Student led questioning | Provide students with an opportunity to engage others outside the class (e.g., family and community members) in scientific discourse and use the collected information to build on content in the classroom |
| Sasha | KWL Chart | Acknowledge students' ideas, thoughts, and knowledge as valuable and helpful in understanding new content<br>Provide students with an opportunity to have ownership over their learning |

The final component of *Phase II* was to have the participants determine indicators of successful border crossing outside those suggested by Aikenhead and Jegede (1999). The teachers reported that increased participation, questions, enthusiasm, excitement, and student-to-student interactions would be key indicators of successful border crossing in their science classrooms. The only challenge the teachers anticipated was their ability to thoroughly implement their methods while simultaneously fulfilling their many administrative and curricular responsibilities.

## Phase III: Research Question 3

*How does awareness and understanding of science culture and cultural border crossing influence urban secondary science teachers':*

*a. perspectives regarding the culture of science and cultural border crossing and their role in science education and,*

*b. teaching practices and classroom culture?*

**Demetri**

It was after learning about the culture of science and cultural border crossing that Demetri concluded that perhaps all science education should focus on facilitating these border crossings instead of getting through content. This differed from his *Phase I* thoughts as he wrote in his survey that science culture is “democratic, logical and tough” (Demetri, *Phase I* Survey). His perspective on science culture changed again in *Phase III* to one that focused on creativity but still recognized the constraints of the culture of school science. He wrote, “I think that science offers students a chance to be creative, yet are given constraints in the classroom to be forced to think logically and systematically” (Demetri, *Phase III* Interview). When asked how this new perspective of the culture of science influenced his instruction and teaching philosophy, Demetri replied:

> Well, I think after this experience, it made me realize that doing the traditional way is even less effective than I thought it was before. Which says a lot because I really didn’t think it was effective before. So now I have to revisit it again and try to figure out exactly at what point are you doing a disservice by teaching the content to students because they’re not actually learning. So that’s a scary thought. (Demetri, *Phase III* Interview)

Demetri always considered himself fortunate as a chemistry teacher in that he had the freedom to use alternative approaches in teaching the chemistry curriculum. During his interview he noted, “because there are no standardized tests [in high school chemistry] I can hold them accountable for what we’ve learned instead of holding them accountable for things that there are other expectations for” (Demetri, *Phase III* Interview). For Demetri, this provided him the ability to be flexible in the way he teaches science and has therefore enabled him to try new methods with an effort to make it more accessible for all of his students. Specifically, he expressed the need of allowing students to pursue their own ideas and interests. He stated in his interview:

> I just think, “how can I make this more practical” and then I try to find a compromise between what I want to do and the traditional route [content heavy curriculum]. I’m always trying to find a compromise, but it might just be better to eliminate the other one completely and just make it purely practical and skills based even in all the sciences at this [high school] level. (Demetri, *Phase III* Interview)

Demetri found that for successful border crossing to occur, students’ own ideas and beliefs about scientific phenomena needed to be supported and learners needed the opportunity to investigate collaboratively as true scientists would. He argued that with traditional approaches to learning the heavy content found in typical science classrooms, students are less likely to cross the borders into science. He stated, “They are stuck valuing the body of knowledge and memorizing. . . . And they are not sure how to reflect, think critically and independently construct the knowledge” (Demetri, *Phase III* Interview). He later supported this notion again by stating the following:

> And I think in the general traditional route when you have the experiments, a lot of these experiments are just not interesting, they’re related to the content, but there’s no, “wow” factor. There’s no . . . it’s more about technique as a preparation to move to the next

academic level instead of what's going to generate creativity and interest. So, it seems like we're doing a disservice. (Demetri, *Phase III* Interview)

Through the debate format, Demetri hoped he could give students the opportunity to "act more like scientists instead of like students" (Demetri, *Phase III* Interview). During the span of his one month implementation period, Demetri was able to complete one debate unit in an effort to facilitate cultural border crossing. He allowed students to select their own topics of interest that they would later debate. Throughout this time, Demetri claimed he saw students more engaged with the content and the science behind their topic then they normally would have been during a standard lesson of his. I witnessed this in his classroom particularly during my second observation of Demetri's debate preparation lesson. The students were involved not only in researching their topic but they were engaging in scientific conversations between themselves and with Demetri. Feelings of ease, flexibility, and playfulness were present like they were during my *Phase I* observations. However, during the debate preparation lessons I observed it was clear that students were now showing these signs not only through off-topic discussions as evidenced in Phase I, but more importantly when discussing and working with content related material. Students were reading one another's notes and providing feedback. One example of flexibility and playfulness occurred between three students while reading one another's points on their debate topic of nuclear warfare:

Student 1 You're right about what caused it, but I still don't get it.

Student 2 What do you mean, you don't get it?

Student 1 Like you are using professor type words, no one is going to know what you're talking about.

| | |
|---|---|
| Student 3 | Yeah seriously [student's name], what do you think they are, Einstein? [students laughed together] No one is going to get it. I mean we get it because it's our topic, but they won't. They are going to think you copied it from the internet<br>[students laugh again] |
| Student 1 | Ok, try to write it in like easier words. |
| Student 2 | Alright give me a few minutes to change it. (Demetri, *Phase III* Observation May 15, 2014) |

**Fabio**

During *Phase I* of data collection, it was determined that Fabio's understanding of the culture of science was accurate and aligned to that of the readings and therefore did not change after *Phase II.* During his *Phase I* of data collection, he noted that science culture was "a culture of very intellect few, a gated community of doctors and of research scientists" (Fabio, *Phase I* Survey). This was similar to his later response when he wrote, "it is perceived as elitists by others outside and within the community. Science culture may be seen as alien or hard to enter/understand by others" (Fabio, *Phase III* Survey).

Fabio's initial ideas from *Phase I* data suggested that his views of cultural border crossings in the classroom occurred only between students' own cultures. According to his survey and interview responses, he did not make the connection between the notion of cultural border crossing and the culture of science. This changed after *Phase II* when it became apparent that Fabio understood that there is a border that exists between students' own cultures and the culture of science. He stated in his interview:

> I always knew it was my students' distinct culture, but I didn't realize how alien it was from science culture and how science culture, no matter what your background is, can seem kind of alienated or disjoined or removed from what everyday life, especially our students' lives. (Fabio, *Phase III* Interview)

The approach he decided to take to facilitate border crossing in the classroom was to make the introductions to his lessons more culturally relevant and better aligned with the daily lifestyles and experiences of his students. He stated that the purpose was to use "real data from the community, usual events around here and trying to make it like you [the student] have a personal connection to science." (Fabio, *Phase III* Survey).

This practice was evident to me during both of my *Phase III* in-class observations of Fabio's lessons. He started both lessons with an introductory activity that pertained to his students' lives and cultures. The first "do now" activity I observed used a true scenario involving a toxic waste spill in the area and how it affects the land and soil that the students live on. He also used the contamination of the nearby river to discuss the effects it had on the population size of trout over the last 20 years. During these lessons, students were engaged in the content and overall feelings of ease, playfulness, and flexibility were noticed. Students shared their data and results and asked each other and Fabio questions that led to further understanding about the content. For example, after identifying the toxin levels in their yard's soil, students wanted to know if they could garden in that soil and what agricultural methods they could use to remove the toxins from the soil. One student playfully joked, "Well I'm definitely not going let my mom garden anymore, well . . . maybe she can and then we can make crazy mutant tomatoes and be on TV" (*Phase III* Observation, May 15, 2014). Fabio supported this method in his survey when he wrote:

> I try and give more conceptual questions where students must use their own experiences combined with logic to solve a problem. I hope that by seeing that their own logic and background experiences can align with scientific practices, they will make an easier transition into science culture as it will seem less foreign and just make sense. (Fabio, *Phase III* Survey)

Fabio began using this practice in his classroom as an introduction to the material and lesson the students would be learning. However, being that he and I saw successful border crossing through these introductory activities, Fabio decided he would continue this practice as a primary component and teaching lens for all of his lessons from that point forward. He stated in his survey:

> I saw them so interested in the science of their own environment that for the first time in my teaching career, students were moving through the content individually then I could teach it. Basically, they were teaching themselves faster and in what I think was a more meaningful way. (Fabio, *Phase III* Survey)

He later expanded on this concept during his interview by stating, "Even though it was intended to be an introduction to the core lesson, most of the times I found students coming to the conclusions before I taught them in the body of the lesson" (Fabio, *Phase III* Interview). Essentially, this led to student driven learning that increased student participation, engagement, and overall excitement to solve the problem that related to them.

**Gabriella**

It was Gabriella who appeared to be most affected by *Phase II.* Her perspective and ideas about the culture of science and border crossing truly impacted her instruction and classroom environment, so much so that these changes encouraged her to implement her own formal, action research within her classroom on the topic. In her research, she decided to ask students to draw a scientist and answer questions for a presurvey she developed. After implementing her proposed methods for several weeks, she later asked the students to complete a postsurvey and redraw their idea of a scientist. Her findings are discussed later in this section.

Gabriella's initial understanding of the culture of science focused on how the scientists were perceived by most, including her, even though she was aware it was an inaccurate perception. She stated, "the culture of 'being smart,' 'educated,' and 'nerdy" (Gabriella, *Phase I* Survey) and later in her interview when she said, "White middle-aged men with glasses in a lab coat and balding . . . I'm aware of that as a preconception, but it's still a picture in my mind although I don't believe it" (Gabriella, *Phase I* Interview). Although Gabriella had an understanding of science culture and how her students perceived it, she had not established the relationship between science culture and science teaching prior to Phase II. She stated, "Understanding what the culture of science is, and understanding that no kids are born there. They have to go back and forth, and I need to know what it is that keeps them out to help them cross it" (Gabriella, *Phase III* Interview). When asked about border crossing and its application in the science classroom, she wrote:

> Awareness of my vocabulary and knowledge (what I take as given for common knowledge) but what it is for most high school students. Awareness of students' stereotypes of what science is and what science careers are and what they think about who can and can't "do science." (Gabriella, *Phase III* Interview)

Gabriella thought that her experiences growing up with parents who encouraged inquiry and science learning contributed to her smooth transition into the culture of science. This in turn could have influenced her inability to realize prior to the study that there are borders that exist between the culture of science and her students' cultures. She stated in her interview:

> Now that I know what that is or that we can talk about it, I realize what turns kids off of science and what makes science intimidating, or scary, or even, if it's not that scary they think of it as "not for me". (Gabriella, *Phase III* Interview)

Gabriella set a goal of having her students move "back and forth between the science world and nonscience world and feeling at home in both places" (Gabriella, *Phase III* Survey). In order to successfully do this in her classroom, she implemented a few measures. First, she gave her students a pre-questionnaire that aimed to determine what students thought about science, whether they saw themselves pursuing a science career, and finally, which science careers they were familiar with. In her interview, she discussed the results of her informal research:

> Many of them wrote about science teachers or wrote about the teacher as a science career, which surprised me . . . but very few kids said they wanted to be a scientist or be in a related field. So there is something keeping them out of that career option. (Gabriella, *Phase III* Interview)

She also asked her students to list the characteristics of a scientist and to draw a picture of what they thought a scientist looked like. She discussed in her interview the results of this presurvey question:

> They wrote things down, also in the survey, "What characteristics does a scientist have?" And [they wrote] they're smart, hardworking, good at school, and the things they wrote about the scientists they drew kind of reflected that too, some of the stuff they talked

> about. They have an idea of what it is to be scientists and do science-hard working, smart, study for a long time and stuff that not everyone wants to do. Buts it's also not the truth and doesn't need to be the truth about scientists. (Gabriella, *Phase III* Interview)

The results of this pre-interview only further encouraged Gabriella to follow through on the border crossing method she discussed during her session. Her goals of incorporating more discussion around the life history of leading scientists, having students research scientists like themselves, and including within her lessons information about the many science related careers that do not fit the traditional image of wearing a lab coat, were implemented over the 7 weeks after the sessions.

During this time, Gabriella said she practiced flexibility with the content and encouraged students to pursue their questions and ideas. For example, during one class a student brought up the idea of charging a cell phone by using a banana. The class explored the phenomenon over the next few lessons, tested different alternative solutions, and independently researched the science behind the possibility. Gabriella facilitated the student led learning and also embedded discussions about the scientific team that developed and tested the iPhone. During these lessons, I watched the students work collaboratively and freely and in a focused manner while also respecting one another's input and ideas as they attempted to troubleshoot and modify the experiment. There was an overwhelming feeling of ease and flexibility as evidenced when new ideas were brought into the discussion or when students asked questions. For example, when the first attempt did not work, a student asked another student, "Why don't you think it worked?" A third student joined the conversation by saying, "Well maybe it has to do with the ripeness of the banana" (Gabriella, *Phase III* Observation, May 7, 2014). This triggered further research on the potential energy in a ripe banana versus an unripe banana. Throughout the lessons, I observed joking around and playful behavior between the students and between Gabriella and her students as they tackled and eagerly explored this problem. Gabriella shared during her interview her experiences with the playful behavior I observed:

> I have noticed more interest by everyone . . . that joking around, interpersonal joking around, not just making a joke out loud for the class, but at each other in a nice way. I see that in other parts of class, most just when we're around the lab tables together. So I think it's good. . . . There's one girl in particular, she doesn't talk to any of them outside class but in the classroom community they are her peers and she collaborates and jokes with them as though they've been friends for years. (Gabriella, *Phase III* Interview)

**Joshua**

During Phase I of data collection, Joshua suggested that he thought his students viewed the culture of science as one that was heavily embedded with questioning and inquiry thought processes. Since science had always come easy to him while growing up, he did not initially view the culture of science as different from his own. This perspective changed as Joshua attended the three sessions during Phase II. In the course of his interview, he explained this change:

> I think I came with these ideas of what a scientist looks like, and what a scientist acts like. I didn't realize inadvertently that I was, I want to say, "culturing" them out . . . almost excluding them because of the way I was approaching teaching it. If you wanted to jump on the bandwagon of the way I was approaching science, it was fine. I would try to get everyone to get there but it definitely was a particular view of what I thought scientists look[ed] like and what they did. (Joshua, *Phase III* Interview)

This made Joshua re-evaluate his teaching practices and how he presented scientific content and material to his students. Like Fabio, he decided during the sessions that he would focus his instruction method to facilitate border crossing by making the introductions to his lessons and activities more meaningful, relevant, and problem based for the students. However, after observing his students interact during these introductory activities, Joshua noticed he wanted to take this a step further. He realized students were deeply disappointed in some of the information they were learning about their community. For example, the students were upset after learning about the increased toxin levels found in their backyard soil. In his interview, he described his students' disappointment, "They were so upset that the soil in their own backyard had small traces of toxins, they wanted to do something about it, they became science activists" (Joshua, *Phase III* Interview). It was during this time of his implementation period that Joshua took on a second approach to facilitate cultural border crossing. In this added approach, the students took on an activist perspective as they attempted to solve presented problems. He decided to allow students the opportunity to work on solving this problem in the community, something that was not originally part of his lesson. In his interview, Joshua described how excited he was to include this new component into his classroom:

> I wanted to have something students could actually fight about and be themselves in a way that scientists do in learning that process of supporting your argument but working on their own set of values, their own goals, their own set of creativity to push them forward. I wanted now to not only do problem based stuff but also have the kids design and test solutions. I want that now to be a regular part of every unit. Every unit we're talking about a problem related to their lives and also potential solutions. (Joshua, *Phase III* Interview)

A critical lesson he learned when implementing this was how important it is to give the students the ability and freedom to explore their various solutions. Prior to this experience, Joshua would teach like there was one right answer and that "science has nothing to do with creativity or having passion for what you're doing" (Joshua, Phase III Survey). Instead, he realized this approach perpetuated cultural borders and changed his perspective to one that gave students more autonomy and ownership over their responses and solutions and further engaged them and made science content more approachable. He argued in his interview that, "even if their solutions or responses were incorrect as long as they could argue their solution or point, in the way that scientists do, I think they're effectively crossing that border" (Joshua, *Phase III* Interview). He later discussed how he believed his students viewed the opportunity of problem solving like a scientist:

> They [the students] are effectively going, "I am myself, and I have values that I'm expressing, and I think that this is the best way to express it. It might be different between students but I'm still doing everything a scientist does and doing it well." (Joshua, *Phase III* Interview)

When asked what evidence he had that students were successfully border crossing into the culture of science, Joshua determined it was his students' sense of pride over their work and in particular, regarding the solutions they designed for each corresponding problem. This was evident in the lessons I observed. Having recently learned about the high levels of asthma in their city and the role pollution played in this common disease, students developed various solutions to filtering the air children breath while at home. Some students took an approach by drawing and writing their solutions while others drew blueprints and began building actual prototypes of their solutions. While observing this lesson, I realized the students were all engaged and worked together to solve their problem. Like Joshua said, they were all obviously proud of their work and eager to share their ideas and thoughts with one another, Joshua, and even myself. Students were at ease when working with the content of the air pollutants and quickly went to the Internet or textbook if they encountered a challenge and needed additional support. They were flexible in their solutions as they provided alternatives and suggestions to one another. Finally, aside from high levels of engagement, students were having fun. I often heard laughter in the room and joking between students. In a classroom that was so traditionally teacher centered and quiet, this classroom was successfully border crossing.

Interestingly, while speaking of the successes he was having in his class, Joshua mentioned how valuable the *Phase II* experience was for him in understanding the true meaning of inquiry. He said:

> I wish they [residency teacher preparation program] had said the whole idea of inquiry by including this cultural stuff. We always talked about inquiry and we never knew what it meant. We've talked about having the students explore, but I don't think that's just what it is about. . . . It's never dawned on me that if I had read the articles we talked about, and had we had the same discussions about inquiry and how students learned science . . . it never dawned on me to think of it like that and its changed the whole way that now I'm thinking about my class. I finally get now what is meant by inquiry, three years later. (Joshua, *Phase III* Interview)

**Lola**

As compared to the rest of the participants, Lola's perspective on the culture of science and border crossing seemed to have changed the most when comparing her *Phase I* and *Phase III* interviews and surveys. Her earlier opinion that science culture was no different from other content cultures later changed to one that appreciated the borders that exist between students' cultures and science culture. She explained in her survey:

> Now that we've discussed this topic with peers my original opinion has changed. . . . I didn't realize that it was elite or unattainable . . . I hope that this misunderstanding of science can be changed and become something that most people value and embrace. (Lola, *Phase III* Interview)

She supported this change in perspective during her interview when she stated, "now that we have discussed it a lot more , it is really everyone outside science that feels separated from science and I didn't see that before" (Lola, *Phase III* Interview). She later attributed this inability to recognize such borders to her upbringing because she was "immersed by people usually interested in science or fit the picture of scientists" (Lola, *Phase III* Interview). During her survey and interview, Lola described her realization of how universal these borders were for students of all demographics. She referred to Taconis and Kessel's (2009) reading of the Dutch students during her survey when she wrote, "I had no idea that this was something that affected students of most demographics, I just think the borders are a little harder for our urban students than my peers in high school, but they still existed" (Lola, *Phase III* Survey).

During the time Lola was going to implement her interview protocol for learning science content and addressing misconceptions, there were several interruptions. She was out of school for medical reasons for a week, followed by another week of testing, and then spring break. For these reasons, Lola said she was unable to implement her strategy as thoroughly as she would have preferred. She assigned students a series of questions that they would ask friends and family members. They were then asked to report the answers they obtained from these individuals to the class. As the lessons progressed, the students were asked to bring up the misconceptions that their family and friends had, and in essence, identify the inaccuracies in the answers they received. Finally, students then reported back to their interviewees in an effort to correct and reteach the prior misunderstandings. Her intention for this was "to see what other people outside of scientific fields thought about scientific concepts, I wanted to bring science to their own worlds outside the classroom and vice versa" (Lola, *Phase III* Interview).

Unfortunately, Lola reported she was unable to implement this in a meaningful way or the way she intended to because of lack of consistency in her schedule. She felt she had not adequately supported her students in border crossing into science culture. She stated:

> For some, it may have been meaningful but I don't think if it would be the same if I had implemented this earlier in the year and without the breaks. . . . I also wish I had done some more actual research and kept data. I feel like if implemented correctly, it would work. (Lola, *Phase III* Interview)

During my both observations of Lola's classes, I did not witness any successful border crossing. This was unexpected considering her interview and survey data suggested a change in perspective. The lessons were primarily focused on literacy skill building, and students often seemed disengaged with nearly no evidence of playfulness or flexibility. Students were not on task completing each assignment, and Lola spent much of the time redirecting students to the content or activity. It is possible that the strict structure was in part because the class was a group of freshmen students with several behavioral issues. This, coupled with Lola's inability to completely implement her border crossing method, may explain the lack of evidence that would support successful border crossing.

**Sasha.** There was no substantial change in Sasha's understanding or interpretation of the culture of science according to her interviews and surveys from *Phase I* and *Phase II*. However, her perspective on the border crossing between science culture and students' cultures in the classroom did change. Like many of the other participants, Sasha was unable to identify the relationship between border crossing and science culture prior to *Phase II.* She later wrote in her survey that the relationship between the two notions "is to promote connections between their own lives and experiences and give students ownership over learning the content" (Sasha, *Phase III* Survey). Prior to the learning sessions, Sasha had an understanding of how science culture differed from her own. However, she was unaware of how, as an African American woman, she could have further perpetuated those borders in the way she taught and approached science with her students. She said in her interview, "I kind of realized how my unconscious ways of teaching science before might have made it even more difficult for my students to be able to relate or understand" (Sasha, *Phase III* Interview). She later described the importance of science educators being aware of these borders, "realizing that we have to change that perception for students to be more connected or feel more connected to the culture of science" (Sasha, *Phase III* Interview).

The use of students' prior knowledge and ideas in the classroom was what Sasha believed to be essential tools in helping students cross the cultural borders into science culture. She explained in her interview:

> I discuss with them my past experiences, whether it was in school or just in general. I try to be more personal and get more personal when I speak about my experiences. When I'm teaching, I try to make science as fun as possible and help them make the connections to their real life experiences so they don't see it as something so far or different from their day-to-day life. That's changed because I was aware of the importance of having students experience it and prior knowledge related to science. I

became more focused on it after our discussion. . . . So specifically try to tailor the questions and the lessons to possible experiences that are more real to them. (Sasha, *Phase III* Interview)

During Phase II, Sasha stressed how important she thought it was to implement the use of a KWL chart as a means of accessing students' prior knowledge, keeping them engaged in the lesson, and allowing students to apply former and current experiences as they learn new content. When she implemented the KWL chart, she ensured that all the students' ideas where included, even if they were incorrect. During her survey, she spoke to the values of this, "I attempt to have them develop as many connections of science concepts to their previous knowledge or experiences. I want their ideas and thoughts to be valued as important in leading the discussion or lesson, right or wrong" (Sasha, *Phase III* Survey). She felt that this was, "making that very clear to them, that you're constantly revising your ideas [in science]" (Sasha, *Phase III* Interview). Additionally, Sasha said, "They have these misconceptions and that it's hard to get rid of them. I felt like the KWL made it easier for them to transition between correct and incorrect scientific knowledge" (Sasha, *Phase III* Interview).

During my *Phase III* observations of Sasha teaching her lessons, she used KWL charts throughout. She had one ongoing KWL chart on the board that represented the whole unit's big idea of the forces that cause evolution. As the unit progressed, students modified the unit's KWL chart within the discussions. For each lesson, Sasha implemented another, more detailed, KWL chart that addressed the concepts of the particular lesson's objective. Sasha described the value of the unit KWL chart:

I kept it up on a white board. There were things that we didn't cover, there were questions that we didn't even answer, and the kids would remember those questions that

> we didn't cover, and if it came up during another concept in one of the unit's lessons, they would point out and say, "remember the K or the W, remember that question?" It's just a constant circle of taking this information and bringing it here, does it apply here? No? Why not? It's just this circle of information. (Sasha, *Phase III* Interview)

The students had ownership over their learning, and although Sasha led the introduction and instruction of new content, the students' own ideas, thoughts, and experiences were valued in the process. In turn, I observed a culture of investment and engagement in their own learning within the classroom community. Students were flexible as they re-engaged with the material they initially had contributed earlier in the lesson and unit. During one lesson, I observed a great deal of playfulness between the students as well as between the students and Sasha. As they referred to an incorrect component of the K (what do you know) portion of the unit, one student brought up how the idea that evolution happens from one generation to another was not a correct statement. Without pointing out the individual student who made that claim, the class jokingly discussed how the statement was incorrect. The conversation between the students is presented below:

| | |
|---|---|
| Student 1 | So wait, then that thing we wrote on the K is wrong? |
| Sasha | What thing? |
| Student 2 | How it happens every generation. |
| Student 1 | Yeah, that's not right, [laughter]. I mean I can't just have a baby that is automatically evolved and will have evolved babies. |
| Student 3 | Yeah, it has to happen to a lot of people at once and over a long time. |

Student 1 So like if my kids had the same change in their DNA but so did everyone kids in this class and it was a good mutation that made it better at surviving?

Sasha Right, many generations and years with multiple organisms. So how can we change our KWL chart, talk to your partners to determine this. (Sasha, *Phase III* Observation, May 7, 2014)

During this lesson, the students worked together to correct their earlier claims and statements all the while using themselves to describe the example. Additionally, this was evidence of flexibility. As the students worked in their groups to modify the bullet on the K side of the chart, they were flexible in making changes and as a class altered the on the board statement to say, "Occurs over several generations and to populations, not just single organisms" (Sasha, *Phase III* Observation, May 7, 2014).

**Phase III: Likert Item Analysis**

The mean values for the Likert items on the Phase III survey can be found in Table 4.4. The values varied for the six Likert items and were dependent on the respective item. Analysis of the mean data indicated that during *Phase III*, the participants had high means (4 or higher) for all the items except when asked to rate their opinion of how science culture is portrayed by students (item 3) and how frequently they believed students crossed cultural borders during any given class period (item 4). This indicated that overall, the participants did understand science culture and see the borders it creates as relevant to teaching and learning of science.

Table 4.4

*Mean Values, Standard Deviations, and Ranges for Responses to the Phase III Survey*

| Likert item | Range | Mean | *SD* |
|---|---|---|---|
| 1. How necessary is the understanding of science culture in the teaching and learning of science? | (1) Very Unnecessary<br>(5) Very Necessary | 4.2 | 0.41 |
| 2. Based on your experience, how significant is understanding science culture to the teaching and learning of science? | (1) Very insignificant<br>(5) Very significant | 4.5 | 0.55 |
| 3. Rate your opinion of how science culture is portrayed by students of diverse backgrounds. | (1) Highly negative<br>(5) Highly positive | 2.2 | 0.41 |
| 4. How frequently do you think students in your classroom cross cultural borders? | (1) Monthly<br>(5) Multiple times/day | 3.3 | 1.37 |
| 5. To be successful in school science how relevant do you think cultural border crossing is for students? | (1) Highly irrelevant<br>(5) Highly relevant | 4.5 | 0.55 |
| 6. What is your position on the following statement, "To be successful in school science, students must learn to border cross between their own cultures and the culture of science." | (1) Definitely disagree<br>(5) Definitely agree | 4.8 | 0.41 |

The mean value for item 1, (How necessary is the understanding of science culture in the teaching and learning of science?) was above neutral with a 4.0 and a standard deviation of 0.41.

For item 2, (Based on your experience, how significant is understanding science culture to the teaching and learning of science?) the mean value was 4.5 and the standard deviation was 0.55. The mean value for item 3, (Rate your opinion of how science culture is portrayed by students of diverse backgrounds) fell slightly above neutral with a value of 2.2 and a standard deviation of 0.4. Item 4 (How frequently do you think students in your classes cross cultural borders?) had a mean value of 3.3 and a standard deviation of 1.37. For item 5 (To be successful in school science how relevant do you think cultural border crossing is?) a mean value of 4.5 and standard deviation of 0.55 were determined. Finally, the highest mean was for item 6 (What is your position on the following statement, "To be successful in school science, students must learn to border cross between their own cultures and the culture of science") with a mean value of 4.8 and a standard deviation of 0.41.

**Paired t test analysis.** A paired t test was used to identify if there were any significant differences between the item means from *Phase I* and *Phase III* of data collection. The results of the paired t test can be found in Table 4.5. Although the sample size for this study was small ($n$ = 6, the data suggest that overall there was a significant change in the teachers' perceptions ($p$ < .05, two tailed).

Table 4.5

*Results for the Analyses of Survey Items From Phase I and Phase III*

| Item | Phase I | | Phase III | | | |
|---|---|---|---|---|---|---|
| | Mean | Variance | Mean | Variance | $t$ | $p$ |
| 1. How necessary is the understanding of science culture in the teaching and learning of science? | 3 | 0.4 | 4.2 | 0.167 | -3.796 | 0.013* |

| | | | | | | |
|---|---|---|---|---|---|---|
| 2. Based on your experience, how significant is understanding science culture to the teaching and learning of science? | 2.8 | 0.967 | 4.5 | 0.3 | -2.988 | 0.031* |
| 3. Rate your opinion of how science culture is perceived by students of diverse backgrounds. | 3.3 | 0.667 | 2.2 | 0.167 | 3.796 | 0.013* |
| 4. How frequently do you think students in your classroom cross cultural borders? | 2.5 | 0.3 | 3.33 | 1.87 | -1.185 | 0.289 |
| 5. To be successful in school science how relevant do you think cultural border crossing is for students? | 2.8 | 0.167 | 4.5 | 0.3 | -5 | 0.004* |
| 6. What is your position on the following statement, "To be successful in school science, students must learn to border cross between their own cultures and the culture of science." | 2.3 | 0.667 | 4.8 | 0.167 | -5.839 | 0.002* |

*$p < .05$

For item 1 (How necessary is the understanding of science culture in teaching and learning of science), the mean values for *Phase I* and *Phase III* were 3.0 and 4.2, respectively, indicating a 1.2 change value. After analysis, it was concluded that there was a significant difference between the two means with a $p$ value of 0.031 ($p < .05$, two tailed). This supports the observations that I made of the teachers. All of the teachers who were able to fully implement their methods of facilitating border crossing had evidence of successful border crossing in their classroom as their students interacted with science.

Item 2 (Based on your experience, how significant is understanding science culture to the teaching and learning of science?) had mean values of 2.17 and 4.5 for Phases I and Phase III, respectively, demonstrating a 2.33 change value. With a $p$ value of .031 ($p < .05$, two tailed), it is evident that there was a significant difference between the *Phase I* and *Phase III* data for item 2. During their *Phase III* interviews, all of the participants indicated that their new understanding influenced their methods of teaching and how they understood their students' learning. For example, even though Lola was unable to fully implement her proposed method, she stated in her survey:

> I think I have always been aware that not all students embrace the idea of science education, but I had no idea that this was something that affected students of most demographics. It is not really that students' cultures need to be crossed but more that science culture allows itself to be cross, and this has now influenced how I plan my lessons and how I try to influence students' perceptions of science. (Lola, *Phase III* Survey)

Joshua also wrote in his survey:

> My methods have changed the way I approach science because I have tried to change the way that we approach science topic by writing problem based intros and this has allowed students to be creative on imagining solutions . . . it allows them a space to be themselves and really imagine themselves as scientists. (Joshua, *Phase III* Survey)

For item 3, the mean values for *Phase I* and *Phase III* were 3.3 and 2.2, respectively, indicating a -1.1 change value. After analysis, it was concluded that there was a significant difference between the two means with a $p$ value of 0.013 ($p < .05$, two tailed). This indicated that the teachers believed their students had a more negative view of science culture after *Phase II* than before it. Not only did the paired t test analysis indicate that there was a significant difference between the *Phase I* and *Phase III* data, it was evident from the interviews and survey data that the participants began the study with the belief that students' opinions of science were generally negative. At some point during *Phase I*, each of the teachers indicated that students were often deterred by the culture of science. However, this was not aligned with the Likert scores. The significant difference in the data for the Likert items indicated that after *Phase II*, teachers believed students perceived science culture even more negatively then they originally did in *Phase I.* It is important to note, they began the study with a negative perception. For example, during Fabio's *Phase I* interview he stated:

> I feel like they have this preconception that if you're smart, you'll do well in science, and that they don't consider themselves to be a smart person that they won't do well automatically. I think they kind of . . . themselves right off the bat right there by having this preconception that, "no, I'm not an honor student, I can't do this," or "science is hard, I don't like it," versus, "I find this topic interesting, I want to learn more about it." They say it's more you either have it or you don't kind of thing. (Fabio, *Phase III* Interview)

For item 4, when asked to determine the frequency with which students cross cultural borders, the mean values changed by 0.8. There was no significant difference between *Phase I* and *Phase III* results as indicated by the $p$ value of 0.289 ($p < .05$). Joshua indicated that he believed that students crossed these borders once a month, a value of 1 on the Likert scale which significantly skewed the data. When asked about this during his *Phase III* interview, he stated:

Sure, I did it because I felt that with the units, we only do those once a month, so the way I interpreted it was that students cross borders once in a unit. I mean I guess at some level they are crossing it several times in a class period to be successful, but my perspective on it was from the big picture mentality. (Joshua, Phase III Interview)

For item 5, (To be successful in school science, how relevant do you think cultural border crossing is for students?), with a change in mean from 2.8 to 4.5, demonstrating a change value of 1.7. The *t* test showed that there was a significant difference between the values from *Phase I* and *Phase III* with a *p* value of .004. This indicated that at the end of the study, teachers believed cultural border crossing was more relevant in order for students to be successful in science than they reported at the beginning of the study.

Finally, for item 6, and most importantly, their sentiments and attitudes about the statement "To be successful in school science, students must learn to border cross between their own cultures and the culture of science" increased significantly. The means were 2.3 and 4.8 for *Phase I* and *Phase III*, respectively, demonstrating a 2.5 change value. As compared to the all the other items, item 6 had the lowest *p* value with a value of .002, indicating a significant difference between *Phase I* and *Phase III* data. This evidence supports the notion that teachers and students benefit when learning about the culture of science and cultural border crossing. Demetri wrote in his survey:

> I have noticed that our students are not exposed to many things in science or in nature, and it is very necessary for them to have a toolbox that is sufficient for doing science. One of those tools has to be being able to border cross in order to succeed in science. (Demetri, *Phase III* Survey)

Sasha also wrote in her survey:

> I have learned that students need to access their prior knowledge in order for them to feel more comfortable with the [science] material because it does more than bridge the gap of their understanding, it makes the content more comfortable and relatable and will give them a better chance in doing better in science. (Sasha, *Phase III* Survey)

**Phase III: Summary of Findings**

After analyzing the data from the three phases, it was evident that prior to the study, all the teachers except for Lola began with the perspective that science culture was an elitist culture that consisted of highly educated individuals and that in order to be successful in such a culture, one must be exceptionally bright and able to manage complex topics. Moreover, the same teachers believed that their students also viewed science as a challenging and more difficult content area to master than any of the other areas they were exposed to in high school science. After the implementation of *Phase II*, analysis of *Phase III* data demonstrated that these teachers' perspectives on the culture of science did not change.

However, this was different for Lola. She began the study with a different perspective on the culture of science than her peers. Lola viewed science culture as no different from the culture of other content areas and referred to it "like another content area that you could be studying" (Lola, *Phase I* Interview). By the end of *Phase III*, Lola's perspective on the culture of science shifted to one that better aligned with the perspective of her peers. She noted this change in perspective when she wrote:

> Now that we have discussed this topic with peers, my original opinion has changed a bit. I knew that science was perceived as a difficult and arduous content area, but I didn't realize it was considered as elite or unobtainable as it is, especially not in other countries. I had always assumed that since America had leaned more in the direction of

> entertainment and pop culture that devaluation of science education came with a devalue of all education, but apparently that is not the truth. This view of science pervades other countries as well. I hope that this misunderstanding of science can be changed and become something most people value and embrace, instead of White, male elitist content. (Lola, *Phase III* Survey)

The participants' border crossing perspectives changed significantly from *Phase I* to *Phase III.* Initially during *Phase I*, most of the teachers believed that when thinking of cultural border crossing in the science classroom this only pertained to the border crossing that took place between the students. This is interesting because the teachers were able to describe science culture but were unable to connect it the creation of additional borders that students needed to cross. It was clear from the qualitative data that after *Phase II,* the teachers were able to accurately articulate the relationship between cultural border crossing and the culture of science. Moreover, they identified that there were significant borders that exist between students and science culture that may compromise students' ability to succeed in science. This change was supported by the quantitative data with significance in the mean values for all but one of the Likert items on the survey. This indicated that the teachers believed the influence of cultural boundaries in science classrooms is substantial and noteworthy in the teaching and learning of science. The only discrepancy that occurred in the quantitative results was for Item 4 on the Likert scale that asked the teachers to identify the frequency of border crossing. After following up with the outlier in the data for this question, it was determined that the teachers' interpreted the wording of the question differently.

In respect to the changes in teaching practices and methods and classroom culture from *Phase I* to *Phase III*, it was evident that Gabriella and Joshua changed the most. The two decided to not only use the methods they proposed during *Phase II*, but to go beyond their recommendations and implement additional border crossing practices once they saw the impact their changes had on their students. Gabriella turned her methods into an action research project to obtain further results on the benefits of her method. She studied how impactful her change in teaching methods was by assessing her students, via a survey and the Draw-a-Scientist Test, before and after she implemented her classroom changes. At the completion of the study, Gabriella had not conducted her post-assessment of her students and therefore could not comment on those results. She did, however, indicate that her students were more engaged and overall more interested and confident when confronting scientific concepts. I witnessed evidence to support the notion that her students were cultural border crossing into science as I observed Gabriella during *Phase III.* However, it is important to note that she had high levels of border crossing prior to the study as evidenced in the data from *Phase I.* Joshua decided to also go beyond the implementation of his method and broadened his method across all of his lessons and units, essentially reframing his whole approach to teaching. I witnessed high levels of border crossing in his classroom during *Phase III,* which was exceedingly different from the classroom culture and border crossing that was demonstrated in his classroom during *Phase I.*

The largest change in classroom culture and border crossing took place in Demetri's, Fabio's, and Sasha's classrooms. The three shared a common culture during *Phase I.* All three had a good relationship with their students on a personal level, and I witnessed multiple instances where feelings of ease, flexibility, and playfulness were demonstrated in their classrooms. However, these indicators of border crossing were mostly observed between the students' cultures and between the students' cultures and their respective teacher's culture. This supported the finding that students were successfully crossing borders between one another's culture and the teacher's culture but were not doing so once they encountered the borders between their culture and science culture. After the *Phase II* and *Phase III*, it was evident that the teachers' methods helped to facilitate this border crossing. I witnessed the three indicators of border crossing not only in the same manner that they were observed in *Phase I*, but also between students' cultures and science culture. There was clear evidence of playfulness, feelings of ease, and flexibility when the students were undergoing scientific practices and when they encountered scientific content, a change from the classroom cultures evident during *Phase I.*

Finally, as mentioned above, Lola experienced several disruptions during this point of the school year that influenced her ability to more thoroughly implement her methods. In turn, I did not witness much change in her teaching approaches or in her classroom culture. On the contrary, there seemed to be less border crossing in my *Phase III* observations of her classroom as compared to those from *Phase I.* Although unable to modify her teaching practices due to circumstances beyond her control, Lola realized the value of understanding science culture and needing to facilitate border crossing as students learn and engage in science. When asked about her implemented methods and their outcomes she said, "I have not been purposeful about it. I'll be honest about that" (Lola, *Phase III* Interview). I asked her if the sessions from *Phase II* influenced her philosophy of teaching science. She replied with:

> I think that what changed more is in general the idea that science is seen as such an elite field. But I don't know the steps to take to change that. It's just now that I'm coming to that understanding and my next step would be, "what do I do about that?" (Lola, Phase III Interview)

This chapter discussed the findings of the study from each phase of data collection. The final chapter, Chapter V, will use the major themes found in the findings and apply it to the larger theoretical frameworks.  The implications and recommendations for further research are also discussed.

# CHAPTER V

# SIGNIFICANCE OF RESEARCH AND CONCLUSIONS

The purpose of Chapter V is to summarize the major findings across the three research questions as they relate to the theoretical and conceptual frameworks that guided this study. The implications of such results, how they may influence further research, and final conclusions are made. As mentioned earlier in the study the three research questions were:

1. What perspectives do urban secondary science teachers have regarding the culture of science and cultural border crossing and their role in science education?
2. How do urban secondary science teachers respond to learning and discussing the notion that science is a subculture that their students must learn to border cross?
3. How will awareness and understanding of science culture and cultural border crossing influence the urban secondary science teachers':
    a. perspectives regarding the culture of science and cultural border crossing and their role in science education and,
    b. their teaching practices and classroom culture?

## Major Findings and Connections to the Literature

After the analysis of each of the three phases of data collection, a summary of findings was created to discuss the results of each phase as they pertained to the corresponding research question(s). The next section of this chapter discusses the major themes that arose across the three research questions. Although summaries of the findings for each phase are discussed in Chapter IV, this next section focuses on the results of the study as a whole. These findings are organized into two areas. The first relates to the culture of science and cultural border crossing, and the second relates to the ways in which teachers can facilitate border crossing in their classrooms.

## Discussion of Themes

After analysis of the three data collection phases, it was determined that there were three larger key findings and themes that related to the culture of science and border crossing. The first major finding was that teachers were aware of, and acknowledged, the characteristics of science culture; they emulated its characteristics in the classroom but did not see the relationship between the culture of science and students' cultures as relevant during the early phases of the study. A second key finding, most evident in *Phase II*, specifically related to the factors that give rise to cultural borders as they pertain to science education. Finally, the last key finding across all three phases was that teachers believed that the current curriculum required them to teach overly complex content and therefore decreased the likelihood of students crossing cultural borders. The three major findings are discussed in detail below.

**Teachers' awareness of science culture but not border crossing.** During the first phase of data collection, it was evident that all of the teachers recognized the characteristics, practices, and aspects that define the subculture of science according to Aikenhead (1999). Additionally, the teachers' opinions of science culture aligned with Shizha's (2007) thinking, that science is a "culture for the privileged, hence a closed culture which is not open to everybody" (p. 305). All but one of the participants (Lola), to some degree, had experienced this in their lives growing up and especially when they became emerged in the culture later as young adults and adults. Five of the six teachers were also able to recognize that their students likely shared similar views of this concept of science culture. For example, Joshua was able identify the characteristics of the culture of science and he believed his students had the same views. He said, "…I think for a lot of them, science looks scary from the outside" (Joshua, *Phase I* Interview). However, when asked to discuss cultural border crossing, he didn't view the culture of science as relevant when he said, "getting to know the students inside and out of the classroom" (Joshua, *Phase I* Survey). Having been able to determine the characteristics of science culture that the participants believed their students share similar view points on, it was unclear during *Phase I* why the teachers were unable to consider this culture when discussing the concept of cultural border crossing.

During *Phase I*, the teachers interpreted that cultural border crossing entailed a multicultural approach to teaching. All of the participants related it to the cultural border crossing between individual cultures within the cultural sharing community that is a classroom. However, even after identifying that there was a distinct culture of science, no teacher thought that there would be a need to also consider the cultural barriers that exist between students' cultures and the culture of science and the pedagogical implications this has on the teaching and learning of science. This is a major finding because it is likely that many other science teachers fail to recognize this relationship between culture of science and cultural border crossing. One explanation for this is that as science educators, they have successfully crossed the cultural borders into science and have therefore experienced cultural congruency in their own science learning experiences. As Krogh and Thomsen (2005) indicated, cultural congruency in science education is determined by one's ability to cross between one's own world and the world of science. This in turn, may have influenced their ability to recognize that science culture may establish additional barriers for those who may not experience similar congruency.

**The factors that create borders in science.** During *Phase I* and *Phase II* of data analysis, it was surprising to find that much of the conversation that took place during these sessions centered on the factors that create borders for students as they attempt to engage in and learn science. Although not directly related to one of the research questions, it was a key finding of the study. Teachers discussed many potential influences that created the cultural borders between urban students' cultures and the culture of science. It was evident from early in the study that most of the teachers felt that the borders were created by the complexity of the vocabulary and the complexity of the content found in science. For example Joshua stated, "the complexity of the language is like, well you can't speak our language so forget you, but I think that continues when teachers go back to the classroom, even I did that at first" (Joshua, *Phase II* Session 1). The teachers also believed the overly complex vocabulary was unnecessary. Gabriella said, " They don't need to know the cell organelles because they already learned in it middle school, and I was like blown away because I didn't in middle school" (Gabriella, *Phase II* Session 1). Thus, cultural capital was necessary in terms of using scientific vocabulary and language, in order to successfully border cross. The teachers argued that science was almost like learning a new language. Sasha claimed, "There are more words in science than many languages have that make up their whole language" (Sasha, *Phase II* Session 2). As supported by many, culture includes its own language. This supports the notion that scientific language creates an additional cultural border (Atwater, 1996b; Banks, 1989; Nieto, 1999).

Secondly, the teachers discussed at length the disconnect that existed between the nature of school science and "real" or authentic science. They determined that the science that schools are often required to teach is not representative of, and is vastly different from, the true science in the field. This indicated that there was little cultural congruency between the culture of school science and the culture that is practiced by authentic scientists. In other words, school science culture is not representative of authentic science culture and creates an additional border for students to cross. What the teachers believed was that students' only understanding of science was through the school science lens and therefore provided students with a false sense of authentic science culture. This was also evident in the images of the scientist that the students shared with Gabriella.

Lastly, much of the data suggested that the students' lack of basic skills, commonplace in many urban schools like City High School, was another factor that created borders in learning complex scientific information. It was also argued by some of the teachers, that additional language barriers for bilingual students would also create such borders. This border, created by language and discourse complexity, supports Brown's (2004) findings that "science discourse, challenges and often conflicts with students' opportunities for learning" (p. 829).

It is important for teachers to be aware of some of the factors that influence and create these borders for students, especially for urban students. Once teachers are aware of the causes of the barriers for students, they are then able to realign their instruction and alter their methods to best facilitate the crossing of such borders by supporting students as they obtain the cultural capital necessary to become successful in science.

**High school science as overly complex.** Another major finding that arose during all three study phases was the teachers' belief that the level of detail and amount of information their students were required to learn was not only one of the reasons why such borders existed, but more importantly, was constraining and limiting teachers' ability to focus on key practices and skills that are commonly used by true scientists. The teachers thought that the amount of content and heavy vocabulary they were required to teach students inhibited their ability to focus on the methods that may facilitate cultural border crossing into science. For example, Lola argued,

> Making them know each level and step of cellular respiration and mitosis is way too much information unless you're in college majoring in biology, I really don't think it's a necessity . . . we are requiring them to be a biologist in high school. (Lola, *Phase II* Session 1)

Not only was this theme evident in *Phase I* and *Phase II*, but most of the teachers at some point in *Phase III* indicated that they wished they could have spent more time working on their proposed methods but were unable to due to curricular and content constraints. Demetri however realized the value and because he had more freedom in his chemistry curriculum, he was able to fully implement his method.

The content-driven curriculum that teachers are required by administration, county, and state to follow supports the notion that school science is not representative of authentic science and prevents teachers from being able to facilitate border crossing. For example, Lola said, "a lot of the contents, like biology has the test, there are just a lot of constraints regarding how fast we have to move through the content we teach" (Lola, *Phase II* Session 3). The participants first described this concern during *Phase I* and *Phase II*. However, once the teachers were able to implement their proposed methods, it was confirmed that in order to successfully facilitate cultural border crossing into the science classroom, some scientific content and curricular standards would have to be sacrificed.

**Student centered and directed learning as key in facilitating border crossing.** Finally, and most importantly, this study found that the overarching theme that best facilitated cultural border crossing in urban science classrooms was to give students the autonomy to take ownership over their own learning. Giving students the opportunity to use their own experiences, prior knowledge, and ways of learning was a key in facilitating border crossing into science. Demetri and Sasha focused on using students' interests and prior knowledge in helping their students to cross the cultural borders with some success. Gabriella, who was already experiencing success in facilitating border crossing in *Phase I*, further helped her students cross such borders by not only using their ideas and questions to guide instruction but by also making science and science careers less intimidating. Finally, Joshua and Fabio's use of relevant Do Now's helped to engage students and for Joshua, truly push student inquiry and therefore facilitating border crossing.

This study provided evidence that through student-driven instruction, where students guide their own understanding of scientific content while remaining interested in their predetermined ideas and questions, cultural border crossing is achieved. This was observed in Demetri, Fabio, and Joshua's classes. In the classrooms that were most successful in facilitating border crossing, it was evident that the teachers acted as the facilitators as students themselves encountered, solved, and perused scientific knowledge. For example, in Demetri's observations after the implementation of student chosen debates, students became more comfortable with the content and investigating the science to support their debate topic. Likewise, in Joshua and Fabio's observations, students used their understanding and frustrations regarding their community environment to encourage further scientific exploration. By stepping back and allowing the students to take control over their learning without the need to cover detailed content and a large array of curricular standards, the students were able to construct scientific knowledge in meaningful and valuable ways. Most importantly, they were successfully playing the role of scientist in the classroom as they crossed the borders that previously existed.

A second component that supported the notion that student directed learning was key in facilitating cultural border crossing was the valuing of students' prior beliefs, experiences, and knowledge when learning new scientific knowledge. This was most evident in Sasha's classroom, but also in Joshua, Fabio, and somewhat in Gabriella's classrooms. These teachers who experienced successful crossings in their science classrooms had focused on this as they implemented their methods. Whether it was using of KWL charts, using students' ideas and questions to lead the content, providing students with the ability to debate exciting scientific content, or using scientific problems that were relevant to the students' lives, the teachers' methods all emphasized the use of students' lives and individual cultures in the building of new scientific knowledge.

In summary, teaching practices that use students' prior experiences, value students' understanding and knowledge, appreciate students' ideas and interests, and relate to students' personal beliefs will give students the ability to use these resources as tools to increase their cultural capital while practicing scientific skills and practices. With an increase in cultural capital, students will gain ownership over their own learning as demonstrated in student centered and driven learning experiences and support cultural congruency between students' cultures and the culture of science. This, in turn, will serve as a path to cross the borders of overly complex content and nonauthentic science practices. Based on the results of this study, using such resources to build on student capital will make science culture congruent with students' cultures and act as a bridge across the cultural borders and enable students to succeed in science. Figure 5.1 depicts the relationships discussed.

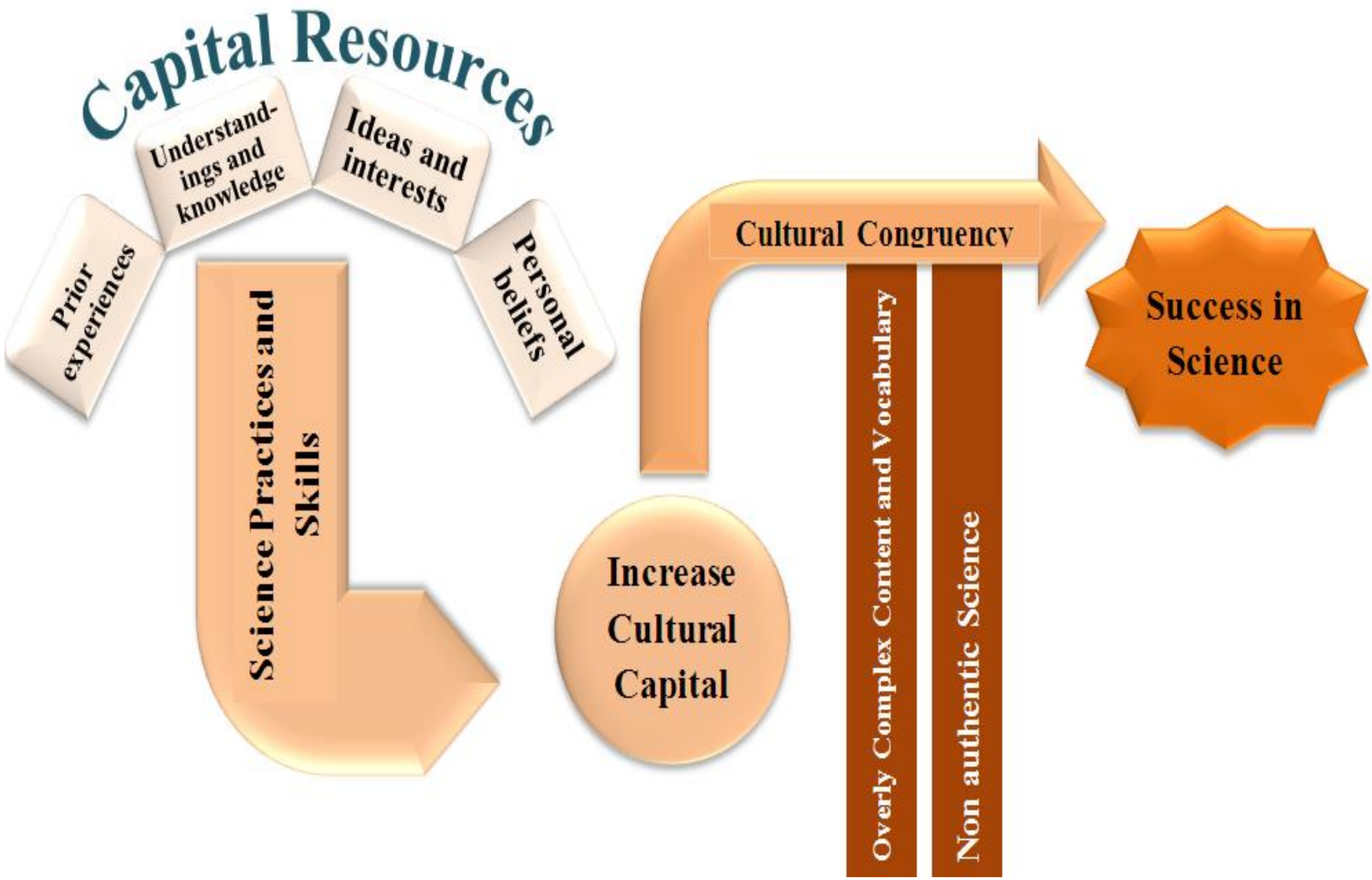


*Figure 5.1.* Summary of the main findings from the three phases of the study.

## Implications of the Study

Although this study was the first of its kind in this area of research as pertaining to cultural border crossing methods in science, it resulted in a change in the way the participating teachers perceived the culture of science and formatted their teaching practices. It has further opened the dialogue on the topic for the participants and will serve as a gateway study to further analyze its importance and value in urban science education. The results of the study provide insight and suggest the need for a shift in the area of science curriculum development and science teacher professional development and training.

### Curriculum Development

According to the results of this study, teachers' perceptions regarding the causes of cultural borders between students' cultures and the culture of science are due to the complex nature and depth of school science. The teachers believed that science practices and skills were often sacrificed in their classrooms due to the curricular constraints that require teachers to teach overly and unnecessarily complex content. As a result, it is therefore recommended, as much science education literature suggests, that curricular changes occur at the state and district levels to support teaching for understanding and doing science rather than memorizing facts. Furthermore, it is recommended that curriculum reflect more heavily the practices and skills that more accurately represent authentic science, a change that is highlighted in The Framework (2012) and The Next Generation Science Standards (NGSS) (2012).

Fortunately, the framework used to develop the NGSS supports this notion proposed by the teachers. It claims that former standards "emphasize discrete facts with a focus on breadth over depth, and does not provide students with engaging opportunities to experience how science is actually done. The framework is designed to directly address and overcome these weaknesses" (NRC, 2012). It is highly recommended that standards and curriculum writers at the state and district levels apply the NGSS as a means of reducing cultural borders in science.

Finally, it is recommended that school administrators permit teachers the flexibility and autonomy to apply methods that utilize students' cultural capital through science practices and skills to facilitate border crossing even if those methods influence the depth and detail of their classroom content.

**Professional Development and Science Teacher Education**

The pursuit of a multicultural research agenda in the field of science education has been supported and encouraged by many (Atwater, 1996a; Barton & Upadhyay, 2010; Lee, 2003; Tobin, 2005). Consequently, it has become standard in teacher preparation programs and professional development to now include issues of diversity and multicultural education. The results of this study, however, indicate that inservice science teachers and teachers in training would benefit by broadening their understandings and approaches to multicultural science education if it also included discussions on the culture of science.

As discussed in the literature review, there are several arguments that support the notion that the culture of science has its own set of beliefs, understandings, and even language causing students to undergo a form of cultural acquisition in order to be successful (Krogh & Thomsen, 2005). Additionally, the elitist culture of science has been discussed as being oppressive, especially for minority students (Aikenhead, 2001; Emdin, 2010b; Lee, 2003; Lee & Buxton, 2011; Tobin et al., 2005). It is for these reasons and as supported by this study, that it is critical for science educators to also obtain an understanding about the culture of science, the borders it creates for students, and the teaching methods and practices that can facilitate such border crossings.  Both professional development and teacher education programs should include this in teacher training as it relates directly to multicultural science education.

## Recommendations for Further Research

### Recommendation 1

For the purpose of this study, a small participant pool was advantageous in answering the research questions.  However, it is recommended that further research methods aiming to address similar research questions be used across various school environments (suburban, urban, rural) and with teachers of different backgrounds and teaching experiences.  This would provide a more comprehensive understanding of the research questions and identify any differences that may exist across demographic groups. As with most studies, when attempting to answer the questions set forth there are usually a plethora of additional questions that arise.  As discussed in Chapter I, one of the limitations of this study included the small and limited participant pool. However, it is important to note that the small participant pool provided for a much more in-depth understanding and analysis while answering Research Questions 1 and 2.   Therefore, the first and most important recommendation below focuses on broadening and expanding the participant pool to further investigate the methods teachers use to facilitate the successful border crossing into science.

### Recommendation 2

The use of the informal PLC model proved to be an advantageous forum to provide teachers with the ability to work together in constructing new knowledge and strategizing ways to overcome challenges in the classroom.  It was evident from the study that providing the teachers with information and literature regarding the culture of science and cultural border crossing positively influenced their approaches and methods in teaching science. It is therefore recommended that further studies use this informal PLC model to help develop teachers in an efficient and meaningful way.

**Recommendation 3**

Recommendations are also made to encourage research on how to better measure successful border crossing strategies that teachers use in the teaching of science. This will allow for further investigations into border crossing teaching methods on a larger scale and within the science classrooms. The methods that were deemed successful in facilitating cultural border crossing in science classrooms were used on a small scale. Although they were seen as valuable practices in reducing the borders that existed, it is recommended that further research be completed to further implement and analyze such practices and how they influence students' abilities to border cross.

**Recommendation 4**

Aikenhead and Jegede's (1999) indicators of successful border crossing, "sense of flexibility, playfulness and/or feelings of ease" (p. 274) were used as the base measure for Research Questions 1 and 3. Although these were used to identify whether students were successfully border crossing, they were difficult to measure in a quantifiable way. It is therefore recommended that research on other potential tools to better measure students' views of science culture and how they change via border crossing facilitating methods be created. This could include, but is not limited to, student attitude surveys or questionnaire tools.

**Recommendation 5**

Due to the restrictions of the school environment where the study took place, a professional learning community model was loosely used in this study. The benefits of having the teachers work through their understandings of the culture of science and cultural border crossing, while sharing their ideas and experiences was deemed an extremely valuable practice. It would therefore be beneficial to further examine how teachers learn about the culture of science in a PLC format as compared to other traditional professional development and teacher education platforms.

## Conclusion

It is evident that oftentimes there is a negative stigma attached to the culture of science, where science learners, especially urban and minority students (Tobin, 2006), are often deterred from succeeding in science due to its unappealing nature. The scope of this research aimed to identify how teachers understood the concept of the culture of science, the cultural borders that exist as students learn science, and potential methods by which teachers could facilitate such border crossings. Moreover, the use of an informal PLC was used as a method to provide teachers with an opportunity to construct new knowledge around the topics discussed and cogenerate potential methods to facilitate cultural border crossing. The results support the value of student driven instruction, where students' capital resources are supported through science skills and practices to facilitate their border crossing and be successful in science. More importantly, the study's results call for a discussion regarding border crossing into science culture as valuable in science teacher education and development. The goal of the study was not only to gain insight about how teachers develop and apply their understandings of the culture of science and border crossing, but to also bring awareness to the need for further research in this area as a means of improving science education and making science more accessible and appealing for *all* students.

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## Appendix A

## Phase I Survey Questions

1. Write about your cultural background and identity.
2. How has your culture and identity influenced your own education?
3. What comes to mind when you think of science culture?
4. What do you think cultural border crossing is?
5. How does cultural border crossing apply to science teaching and learning?
6. What are some proposed methods of facilitating students' cultural border crossing into school science?
7. What are some proposed methods in facilitating border crossing between students?
8. How necessary is the understanding of science culture in the teaching and learning of science?

| Very Unnecessary | Unnecessary | Somewhat Necessary | Necessary | Very Necessary |
|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 |

9. Based on your experience, how significant is understanding science culture to the teaching and learning of science?

| Very Insignificant | Insignificant | Somewhat Significant | Significant | Very Significant |
|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 |

10. Rate your opinion of how science culture is portrayed by students of diverse backgrounds.

| Highly Negative | Negative | Neutral | Positive | Highly Positive |
|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 |

11. How frequently do you think students in your classroom cross cultural borders?

| Monthly | Biweekly | Weekly | Daily | Multiple Times/Day |
|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 |

12. To be successful in school science how relevant do you think cultural border crossing is for students?

| Highly Irrelevant | Irrelevant | Somewhat Relevant | Relevant | Highly Relevant |
|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 |

13. What is your position on the following statement, “To be successful in school science, students must learn to border cross between their own cultures and the culture of science.”

| Definitely Disagree | Disagree | Somewhat Agree | Agree | Definitely Agree |
|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 |

# Appendix B

## Observation Protocol

Observer:
Observed teacher:
Date:
Time: Block:
Objective:
Overall lesson agenda:

| Time | Descriptive Notes | Reflective Notes |
|---|---|---|
| | | |

Appendix C

Phase I Interview Protocol

Time of Interview:
Date:
Place:
Interviewer:
Interviewee:
Position of interviewee: (Briefly describe the project)

**Questions**

1. Describe your cultural and ethnic background.

2. Describe your science education history.

3. What was science like for you during high school?

4. What comes to mind when you think of the culture of science?

5. Describe the culture(s) of your students.

6. How do you think your students view the culture of science?

Appendix D

Days 1, 2, and 3 Session Overviews

**Session 1**
**Topic**: The Culture of science
**Readings:**

- Costa, V. B. (1995). When science is "another world": Relationships between worlds of family, friends, school, and science. *Science Education, 79,* 313-333.
- Meyer, X., & Crawford, B. A. (2011). Teaching science as a cultural way of knowing: Merging authentic inquiry, nature of science, and multicultural strategies. *Cultural Studies of Science Education*, *6*(3), 525-547.
- Taconis, R., & Kessels, U. (2009). How choosing science depends on students' individual fit to "science culture." *International Journal of Science Education*, *31*(8), 1115-1132.

**Discussion Points:**

- Review concepts from the three articles.
- What are your thoughts on each of the articles?
- Do you agree with the authors' perspectives of science culture?
- As scientists, do you feel you can relate to this science culture?
- What effect does this perspective have on how you teach?
- How might this affect how students learn science?

**Session 2**
**Topic**: Border crossing and science teaching
**Readings:**

- Aikenhead, G. S. (2001). Students' ease in crossing cultural borders into school science. *Science Education, 85,* 180-188.
- Aikenhead, G. S., & Jegede, O. J. (1999). Cross-Cultural science education: A cognitive explanation of a cultural phenomenon. *Journal of Research in Science Teaching, 36*(3), 269-287.
- Phelan, P., Davidson, A., & Cao, H. (1991). Students' multiple worlds: Negotiating the boundaries of family, peer, and school cultures. *Anthropology and Education Quarterly*, *22*(3), 224-250.

**Discussion Points:**

- Review concepts from the three articles.
- What are your thoughts on each of the articles?
- Do you agree with the authors' ideas of cultural border crossing as it relates to school science?
- Do you believe this phenomenon exists? If so, from your experiences, which students have a harder time border crossing?
- Have you experienced issues with border crossing into school science in your own science learning?

- As an educator, what challenges, as they relate to border crossing, have you seen students encounter as they learn science?
- What implications do you think this has on science teaching and learning?

**Session 3**

**Topic**: Practical implications
**Discussion Points:**

- Review major points about the first two sessions.
- How has learning about the concepts of science culture and cultural border crossing influenced your teaching practices?
- What are some methods or teaching practices we can implement that may help facilitate cultural border crossing?
- What might be some indicators that students are successfully border crossing?

## Appendix E

## Phase III Survey Questions

1. What comes to mind when you think of science culture?
2. What do you think cultural border crossing is?
3. How does cultural border crossing apply to science teaching and learning?
4. How have your understandings of your students and how they learn science changed through this process?
5. Have your methods of teaching science changed after learning about cultural border crossing? If so, how? Please be specific.
6. What methods, if any, did you find successful in facilitating cultural border crossing into science culture and what was the evidence to support the success?
7. How has this experience influenced your development as a teacher?
8. How necessary is the understanding of science culture in the teaching and learning of science?

| Very Unnecessary | Unnecessary | Somewhat Necessary | Necessary | Very Necessary |
|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 |

9. Based on your experience, how significant is understanding science culture to the teaching and learning of science?

| Very Insignificant | Insignificant | Somewhat Significant | Significant | Very Significant |
|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 |

10. Rate your opinion of how science culture is portrayed by students of diverse backgrounds.

| Highly Negative | Negative | Neutral | Positive | Highly Positive |
|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 |

11. How frequently do you think students in your classroom cross cultural borders?

| Monthly | Biweekly | Weekly | Daily | Multiple Times/Day |
|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 |

12. To be successful in school science how relevant do you think cultural border crossing is for students?

| Highly Irrelevant | Irrelevant | Somewhat Relevant | Relevant | Highly Relevant |
|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 |

13. What is your position on the following statement, "To be successful in school science, students must learn to border cross between their own cultures and the culture of science."

| Definitely Disagree | Disagree | Somewhat Agree | Agree | Definitely Agree |
|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 |

Appendix F

Phase III Interview Protocol

Time of Interview:

Date:

Place:

Interviewer:

Interviewee:

Position of Interviewee: (Briefly describe the project)

**Questions**

1. How has your own identity, cultural background, and experience influenced your teaching methods? If yes, can you provide examples?
2. What has changed about your understanding of cultural border crossing?
3. What has changed in your methods of teaching after learning about cultural border crossing?
4. How do you interact with your students (through a cultural border crossing lens)? How can you facilitate cultural border crossing between your students?
5. What can you take from this experience?