APPROVAL SHEET

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Abstract

Rooted in sociocultural learning theory and stemming from Luis Moll's funds of knowledge research, this study explores how educators can apply students' out-of-school lives to secondary science content. This inquiry was conducted as a collaborative ethnographic study of a teacher and her class of students who "would not typically take chemistry in high school." It focuses on how the teacher built a learning community that incorporated diverse students' funds of knowledge. Rather than just getting her students to pass the class needed for college admission, this study shows how one teacher was able to move her students from the margins of science learning toward the epicenter of a science-understanding community.

Student-centered Funds of Knowledge in the Chemistry Classroom

Lori M. Edmonds

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Dedication

I dedicate this study to the steadfast and caring science teachers who strive to meet the needs of all of their students as their classrooms become increasingly diverse.

Acknowledgements

Without the love and support of many, I never would have accomplished the milestone of earning my Ph.D. I am greatly thankful to my mother, Pat Edmonds, who nurtured my love of language, science, and learning from the time I was a young child. She edited my dissertation, draft after draft and year after year. During the final months of writing, she even cooked dinners so that we wouldn't starve. Many thanks go to my husband, Ashraf Fouad, who endured the eight long years it took me to complete my degree despite my having told him I would complete it in half that time. Perhaps most impacted by my decision to get my Ph.D. was my son, Coby, who was only one year old when I began this endeavor. I am so thankful that while I was writing my final chapters, he was willing to attempt to become a world-class Wii gamer. I am truly fortunate to have had such a supportive and loving family.

Thank you to my amazing academic team. Dr. Nancy Rankie Shelton was not only an extremely supportive mentor, but also became my dear friend. She helped me to develop the research skills I needed, she guided me through the academic interview process, and helped me learn how to balance work and family—although I clearly haven't mastered that balance yet. Dr. Jodi Crandall took me to present with her at conferences and introduced me to experts in my field. She always made time to help me and continued to support me even after she found her retirement from UMBC landed her inundated with work. Dr. Luis Moll was invaluable in his expertise in Funds of Knowledge research and was also gracious in his willingness to remain on my committee after he, too, had retired. Dr. Jennifer Maher taught me that when it comes to analyzing discourse in science, it truly helps to be able to see the bad in everything. Dr. Susan Blunck brought valuable science education insights to my work. I could not have asked for a better dissertation committee to guide me across the finish line!

I can't express enough how fortunate I feel to have had the opportunity to collaborate with an amazing educator. Dana committed countless hours to sharing her knowledge about teaching science to high-school students and sharing stories that enabled me to understand better the complex daily life of a secondary-science teacher. I am also indebted to her for her willingness to let me observe her teaching for months on end. I hope our collaborations will continue as we both advance to new stages of our academic careers.

Finally, I would like to thank the community college professors who influenced me early in my college education. Dr. Lucy Laufe helped me to realize my potential as a college student and provided the social capital I needed to gain admittance to and obtain scholarships for the Honors College at UMBC. The very entertaining history professor, Dr. Kurt Borkman, introduced me to intellectual history which later led me to research the role history plays in how one perceives the world and how that impacts how one learns. I also learned from him that teaching is an art and how one teaches has a lot to do with whether or not students learn.

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Chapter 1: Introduction

Background

During 2005-2007 I developed, implemented and researched a secondary after-school program, LEAP (Language through Environmentally Active Programs). The study was an inquiry into using an English for Speakers of Other Languages (ESOL) program to bridge the communication gap between immigrants and environmentalists sharing Maryland's waterways. The findings revealed that the eight participants held different conceptualizations that affected how they cared for the environment. The program was based on Luis Moll's Funds of Knowledge (1992) research which demonstrated that students benefit academically when teachers connect classroom content with students' out-of-school lives (González, Moll, & Amanti, 2005). As I studied equity in education issues during my doctoral program, it occurred to me that the different conceptualizations that my after-school students held would affect their learning, especially in science, yet as I searched for studies that applied the research to formal secondary science education, I found little. I also recognized that I had changed the original Funds of Knowledge (FofK) Approach to fit the needs of an ethnically-, racially-, and socioeconomically-diverse population, whereas the original study (and FofK studies since then) focused primarily on programs for students coming from one community. I wondered if my version of Funds of Knowledge--I call it "Student-Centered Funds of Knowledge" (SCFoK)--would benefit secondary science teachers who taught students coming from diverse backgrounds. For example, if the approach were used with ESOL students as well as African-American, Caucasian, and other English speaking students coming from a variety of cultures learning in a single class room, would they all benefit?

Later, in another project, I was able to collaborate with a secondary biology teacher, who taught a class made up of students who came from all across Baltimore, during the 2008-2009 school year. Nearly half of the students spoke English as a second language. Other students were non-ESOL students coming from a variety of Latino, African-American, Native American, or Caucasian cultures. I participated in the class two days per week by offering assistance to the ESL students and once per week I collaborated with the science teacher. She would explain student dynamics and science curriculum challenges to me and I would help her with understanding the needs of her ESL students. We also developed together a FofK unit on ecology. The unit began with ESL students completing a Native Animal Project in which they introduced information about a favorite animal (native to their native environment) to the class. Later the students learned about food webs and food chains. Here's what the teacher wrote after completing the unit:

> Overall, the lesson was very successful. The ESL students [derived] more information because they had a context in which to put their new information (food webs/food chains) with what they already knew (their native animal and their native countries). Their peers (students who did not do a native animal project) benefitted by learning about their classmates' cultures. All students benefitted by using ecology words in context (producer/ consumer, primary/secondary/tertiary consumer, food web, food chain, herbivore, carnivore, omnivore). I would use this lesson again in the future.

> I would also like to use the FofK Approach earlier in my units as well. For example, when we were studying macromolecules in our Energy and Matter unit, it would have been really nice to have students think of and analyze their native foods. By sharing their native foods, students would have also been able to analyze the macromolecules present in these foods (carbs, proteins, fats) and their monomers (monoscaccharides, amino acids, lipids). Ecology, however, lends itself to this lesson very well because they were able to think of the bigger picture for Biology - where they are from, what they have seen, and how their prior knowledge related to the new information that they were learning in Biology.

This experience encouraged me, indicating that using this approach in formal education settings at the secondary level might be quite effective. I was especially interested in locating an educational setting that included students who were African American, Asian (ESOL or non-ESOL), Caucasian, Latino (ESOL or non-ESOL), Middle Eastern, and a variety of other ethnicities as well as students coming from different socio-economic backgrounds because more and more this represents the student population in Maryland public schools. My interest was in 1) learning how secondary science could be taught so that all students are able to identify with the content, and 2) focusing on the ways in which science teachers can engage ethnically-, racially-, and socioeconomically-diverse students (Throughout this study, I will use the term "diverse students" to refer to students who are ethnically-, racially-, and socioeconomically-diverse).

With this vision, I began to consider the different schools in which I was involved. As part of my work at the university, I supervised teacher candidates during their student teaching at various secondary schools. I was also a liaison for a PDS (Professional Development School). As I was reflecting on these schools and considering possible locations, I noticed something that interested me at one of the schools where I was supervising a teacher candidate. One day a student of Brazilian descent approached the chemistry teacher, who mentored the teacher candidate I was there to observe, and told her that he missed her. She responded by saying, “You missed me just since yesterday?” He responded, “Yes, I like you. You’re my favorite.” During class the teacher and teacher candidate took turns leading the class. I noticed that when the mentor teacher was leading the class, there was more student participation than what I typically observe in secondary classrooms. I started to wonder what this teacher did that resulted in such high levels of student engagement. The next time I visited this classroom, I overheard an African-American male student telling the mentor teacher, “I like this class.” The teacher responded, “You do?” and the student elaborated, “Yeah, you and Ms. [Bell] are the only black teachers in the school.” I wondered how much Dana’s race impacted students’ engagement and whether there were also things she was doing that made them want to participate. It also occurred to me that Dana’s physical attractiveness may play a role in student engagement; however, she was not a particularly young teacher. There was probably about a 20-year age difference between her and her students.

As I contemplated the idea of doing my research with this teacher, I thought about how unusual it is for an African-American female to be a chemistry teacher. Although roughly 53 percent of chemistry teachers are female, only two percent of chemistry teachers are Black or African American (Smith, 2002). Also, I was interested in understanding why it was that her students were so much engaged in learning chemistry.

It occurred to me that my earlier research could be further enriched by studying this teacher to learn about the techniques and strategies she used to help her students identify with the content in addition to focusing on using an SCFoK approach in the chemistry content area.

My story of learning science.

I was only six when I began to study science; well, five if you include what I learned through an incident with my first pet. We were going away for the summer, so my parents carefully packed our belongings, including Goldie. Goldie sat on a table, in a small glass bowl, in our rented cottage on a lake. It seemed to me to be the perfect place to spend the summer, but my mother did not agree. She complained of a strong mothball odor.

Days after moving, Goldie died. With tears in my eyes after watching her lose her ability to swim and her gills cease to move, Mom stated that the mothballs killed my fish. How could that be? There were no mothballs in the fishbowl. She explained that contaminants in the air eventually end up in the water. I thought about this and wondered whether mothballs really could do all that. This was my first recollection of having scientific inquiry; although I never found out definitively whether the mothballs were the active agent in killing Goldie.

My mother probably didn't realize that she had just taught me that species and chemicals interact and that these interactions have an effect—sometimes a very powerful one. I wondered, if mothballs killed Goldie, what would they do to me as I lay in my bed sleeping, breathing, inhaling the scent?

Later, we moved into our new neighborhood, where, around the age of six, I became friends with a girl who liked to catch the toads that lived in her window wells. Learning where these little critters lived opened up a new world to me. I brought one home and my mother told me that if I was going to keep it, I would have to make a habitat for it. She gave me a box and sent me outside to collect all the things a toad has in its habitat. I covered the bottom of the box with grass, sticks, and rocks and added a small bowl of water. A couple of days later, the toad was dead. I got a new toad, but it, too, died. My mother scolded me, "If you are going to keep toads, you are going to have to feed them so they don't die!" I explained to her that I had fed them and I showed her the clumps of grass I gave the toads. She told me that toads don't eat grass and she had me get out the encyclopedia so we could learn how to care for them.

During my childhood, my friends and I collected many toads and other small animals. Having learned how to study about animal habitats in the encyclopedia and gaining experience as I took care of these animals, I had better luck with future wildlife.

Finally, as a young teenager, I was a breeder of live-bearing fish. I had three large tanks with over 200 fish. But, one night I had a problem: one of my black mollies died on the very day she was due to give birth. I went to my father and asked to borrow his microscope and a razor. Because he had taught me how to look at other things under the microscope, I was very familiar with how it worked. After using the razor to slice open the belly of the dead molly, I placed the clump of emerging fry (recently hatched fish) under the microscope and sat all night watching. Using an eyedropper, I placed droplets of water on the clump to keep the fry from drying up. One-by-one a fry would wiggle its way free from the clump and I would place it in a small fry tank. By the next morning, several of them were swimming. Only a few had died.

These experiences not only grounded me as a young scientist, but contributed to my later understanding of sociocultural theories of learning.

Research Paradigm

This research, which focuses on secondary science education in diverse classrooms, is rooted in sociocultural learning theories, but also draws on critical theory. I begin by discussing the sociocultural nature of this research and then turn to a discussion of its critical aspects.

Sociocultural Learning Theory (SCLT) applications focus on what students know from their social interactions at home and in their communities. Sociocultural learning applications, such as FofK (Moll, 1992), seek to make education equitable for *all* students by valuing their cultural background and using it as part of the learning event. Lev Vygotsky introduced the first systematized sociocultural approach to learning (John-Steiner & Mahn, 1996). Vygotsky claimed that "higher mental functions in the individual have their origins in social life…[and] that higher mental functioning is mediated by tools and signs" (Wertsch, 1990, pp. 113-114). In other words, Vygotsky asserted that learning takes place through social activity that is mediated through language.

Using a story about my own sociocultural identity as it relates to science learning, I will illustrate how issues of identity are perceived and addressed through a sociocultural perspective.

What is Sociocultural Learning Theory?

Experiences are important to learning. Traditional education focuses on learning that takes place within the four walls of the classroom. Sociocultural learning theories look at the learning that takes place within the social and cultural contexts of our everyday lives. It took a certain sociocultural environment for me to have 1) envisioned myself attempting to save the fry mollies (see Identity below), and 2) to have had the knowledge necessary to perform this type of operation successfully (see "Practice" below). Although school was connected to my sociocultural environment, it was not where much of my learning took place. I learned a significant amount of science through social participation outside of school. While this is true for many children, the types of science-related activities vary greatly and the types of information relayed by caregivers is also quite varied.

Etienne Wenger (1998) discusses four components (meaning, practice, community, and identity) that must be integrated when characterizing social participation as a process of learning and knowing. I will use the story above to discuss Wenger's components of a social theory of learning. Within the discussion of sociocultural learning theory, I will also draw from Karen LeFevre's *Invention as a Social Act* (1987) to include cultural aspects of a social learning theory that Wenger does not include in his model.

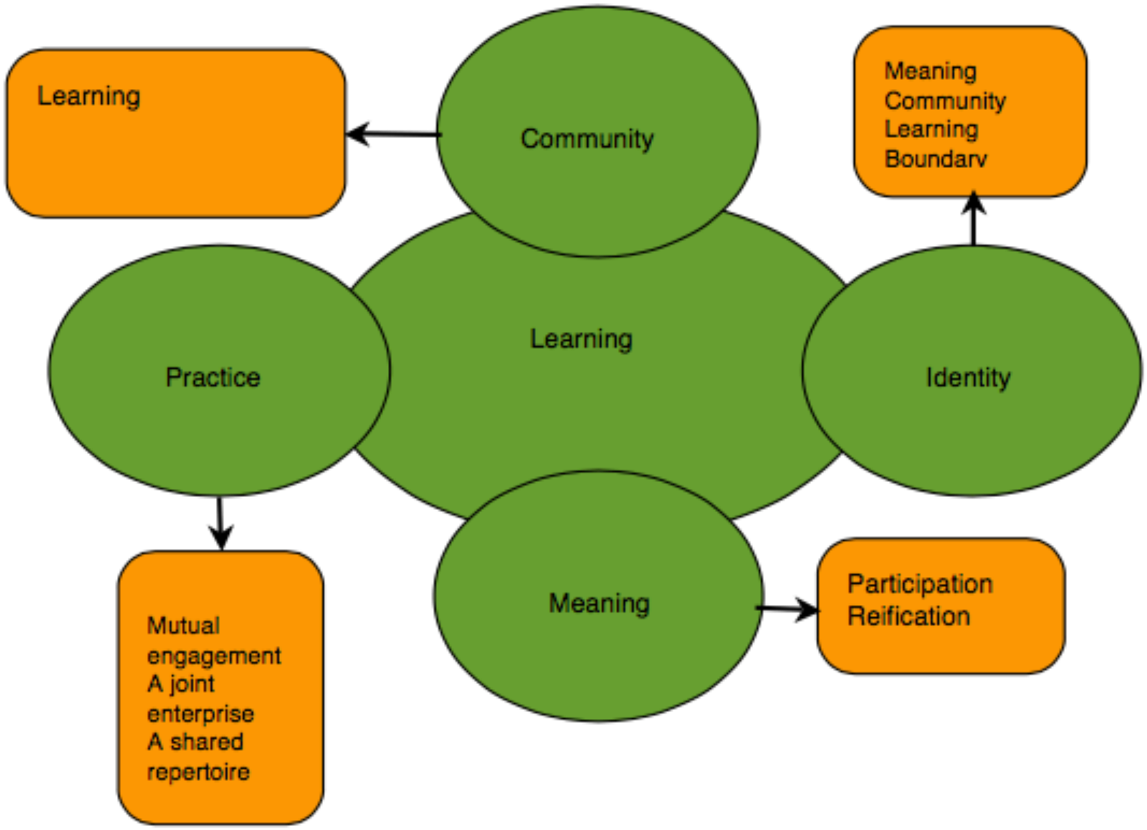

Figure 1: Social Learning Theory Terminology

Wenger (1998) defines meaning as "a way of talking about our (changing) ability--individually and collectively--to experience our life and the world as meaningful" (p. 5). The word "changing" is important because we actually negotiate meaning as we participate in a learning community. In the vignettes, I interacted with animals, and with my parents (who were sources of knowledge), as I made meaning of how life interacts with (and is part of) the environment. These early events informed my negotiation of meaning in how I conceptualized science—or, at least, that part of life that people from my Anglo-American culture refer to as science. When people from my culture talk about science-related topics, they mean modern Western science, unless they state otherwise.

With my Mother's assistance, I learned as a small child that fish are fed one small pinch of food each day and the water in their bowl is changed each week. I also learned from her that the water must sit in a jug for a day before it can be put into the fishbowl so that the chlorine will dissipate rather than kill the fish. Because I was emotionally attached to my fish, these facts were very meaningful to me. With my mother's help, I participated in a practice that introduced me to modern science by teaching me to 1) measure (a pinch of fish food), 2) pay attention to intervals (daily feedings and weekly water changes), 3) avoid certain chemicals (chlorine, and mothballs [naphthalene]), and 4) observe behavior (ability to swim, movement of gills). This negotiation of meaning also involved reification--the concept that forms have meaning beyond their original context. Mothballs were invented to kill moths and their larvae; however, to me they became associated with the death of my pet and a possible health risk to me. Vygotsky (1978) would explain the learning that took place with my mother's help in terms of "the zone of proximal development" (ZPD), which refers to the difference between what learners can do independently and what they are able to do with more knowledgeable assistance.

During my adolescence, I negotiated meaning through participation and reification that was far more complex than what I learned as a child because all the years that led up to my adolescence, had a history of participation in the practice of modern Western science. When I decided to operate on the pregnant molly--a decision in which my identity played a great part (see Identity below)--I was no longer an apprentice of my mother. I was able to participate as a surgeon-like practitioner to save the unborn fry. I was able to use instruments both as they were meant to be used and in ways that were never intended in order to be successful in the operation. Using the dull end of an embroidery needle to separate a wiggling fry from the others is an example of the tool reification that took place as my identity moved toward the realm of a science community of practice (see Figure 2).

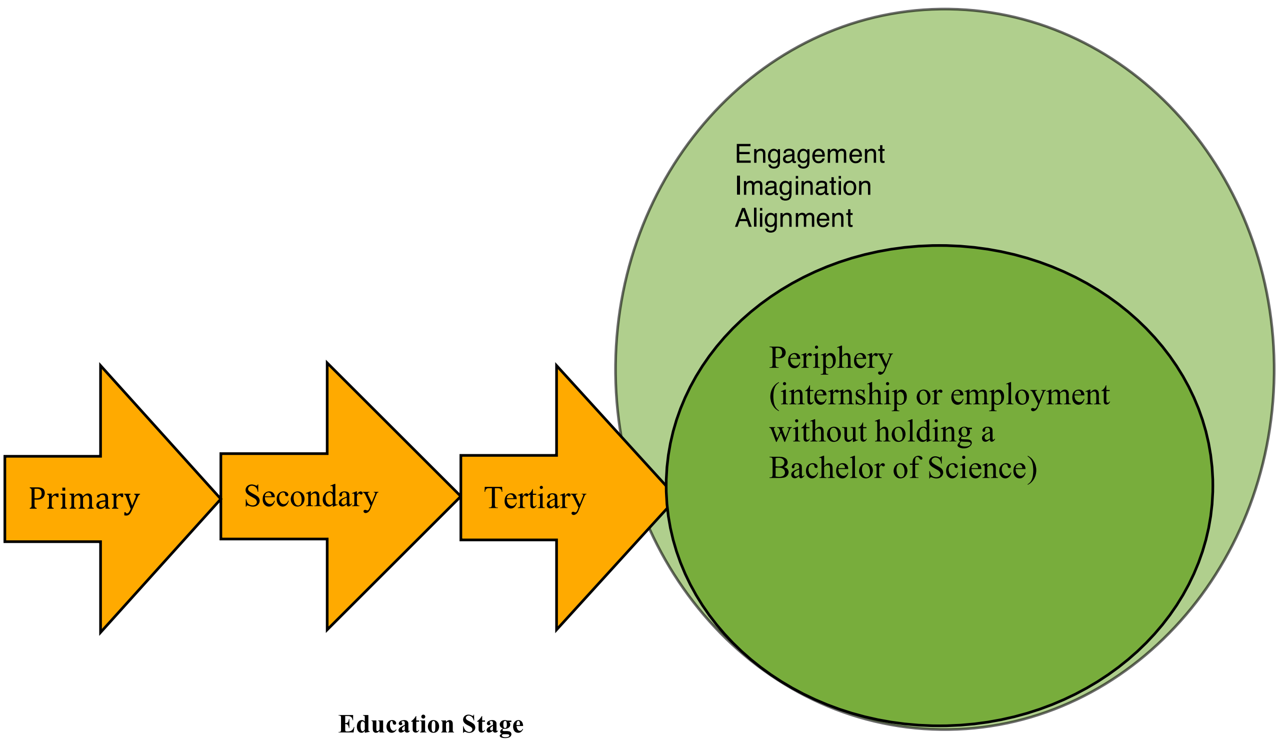

Figure 2: Entering the Field of Modern Western Science

Practice as defined by Wenger (1998) can be discussed in terms of meaning, community, learning, boundary, locality, and knowing. Below, I discuss how my learning of science through practice and community necessarily resulted in a shared repertoire of science tools, artifacts, concepts, discourses, styles, stories, and historical events that were particular to the middle-class Anglo-American society of which I am a member.

Through practice I learned a certain worldview of science, a modern Western scientific belief system. That is, my parents, being members of a social class that went to college and, therefore, were required to take certain college-level science courses gave me access to certain knowledge, means of obtaining knowledge, and reification. Belonging to this community also meant I was socialized to think about science in a particular way. As a mainstream[1] child living in a mainstream community, I was enculturated into a Western modern science belief system. Western modern science is a particular way of perceiving science-related topics that may differ from the way that people coming from other cultures perceive the world.

As I grew and became more and more enculturated into a Western modern science belief system, my identity also grew to where I eventually became an apprentice of modern Western science. In my culture, learning science included learning to use tools to study nature. As I became more knowledgeable in science, the tools in my repertoire grew so that I was using more of the same tools that modern Western scientists use. For example, as a small child my tools allowed me to observe and maintain a fish (a glass bowl, food, water). As a young teen, my father granted me access to his microscope and chemistry set. I was also allowed, by my parents, to use a razor blade as a makeshift scalpel. At the age of 15, I was awarded an internship by the biology teacher at my

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[1] Middle-class Anglo-American society is, generally, the dominant group in the U.S. For that reason, I sometimes refer to it as "the mainstream" and to groups that are not part of that culture as nonmainstream. These terms are used in order to discuss and compare differences in a comprehensible way and are not meant to stereotype or further "minoritize" any group.

[2] All names of people, schools, and newspapers are pseudonyms in order to protect the

school and a doctor who studied cancer. I was an assistant to a research assistant at NIH. There, I truly was an apprentice in a community of practice of modern Western science and I was taught to use a microscope to perform new tasks, such as counting colon cancer cells and comparing growth rates among cells that had received different cancer treatments. During that internship, I also learned to work under a ventilation hood and to use a centrifuge and an incubator. By wearing a white lab coat, I was visibly becoming distinguishable as belonging to the scientific community, yet my age and lack of paid employment and a degree kept me in the periphery. I made scientific artifacts by preparing slides for researchers to study and by preparing flasks containing cancer cell cultures. Each of these experiences, from when I was a small child through my internship at NIH, took place within a sociocultural context. That is, my position within my culture was being affirmed each time I was given a higher level of responsibility with the tools that are valued by my culture. Through my practicing science along with others, I was able to deepen my understanding of what science means (to my mainstream American community). Within the context of my community, I was able to understand how the boundaries of my science practice expanded as I learned to practice science in ways that more and more closely resembled the way modern Western scientists practice science.

From a young age, my scientific thoughts were formed by those around me. What was ingrained in me was the importance of scientific knowledge to promote life among animals. Had I been from an Indian culture, for example, my first scientific inquiry would likely have been very different. An ESL student from India, Arun[2], once told me a story about how the water that flows from the Ganges River flows from the feet of God. He also told me that any carnivorous animal that is found near the river is killed because the Indians consider the river to be divine and they want to keep it clean (see Appendix A for transcript). From this story, one can see a contrast in my scientific worldview and Arun's. My worldview was related to a Christian worldview that places man in dominion over animals (Genesis 1:26). Arun, on the other hand, seems to have had a worldview that valued the river more highly than carnivorous animals. His worldview was probably associated with writings from the *Rig al Vedas.* Both the *Bible* and the *Rig al Vedas* depict historical events that comprise our different shared repertoires and affect our conceptualizations of science.

Arun's classification of an animal seems to depend on whether or not it is carnivorous; whereas, my classification tended to notice whether an animal was a live-bearer or an egg-layer. Additionally, his discourse of science at the secondary level included terms such as "God" and "divine." I, on the other hand, had been enculturated not to use any terms that Western culture associates with religion when discussing science. The LEAP after-school program in which Arun participated was designed to use an SCFoK approach. In so doing, the program facilitators were careful not to dissuade students from drawing from their spiritual beliefs in discussing the environment. Furthermore, students were encouraged to make connections between their native culture and the environmental activities in which we were engaged. Also important is the fact that LEAP participants

[2] All names of people, schools, and newspapers are pseudonyms in order to protect the identities of those involved with this study.

were never directed to classify environmental discussions as scientific discussions. It is not safe to assume that all cultures perceive environmentalism as belonging to the sciences.

In framing a discussion on identity, Wenger (1998) defines three modes of belonging: engagement, imagination, and alignment. The discussion below also draws on my personal experiences to explain each of the modes.

Engagement is "active involvement in mutual processes of negotiation" (Wenger, p. 173). As I grew up being engaged in different science activities, my identity (as I saw myself, as well as how others perceived me) changed. Even though all of my activities up until I began an internship at NIH were outside of the scientific community, my levels of engagement (along with my growing knowledge base) eventually became noticeable to my biology and anatomy teacher so that he recommended me for the internship, which gave me admittance to the periphery of the scientific community. Indeed, during these high-school years, my interest with science became so involved that the lines between formal (classroom) science learning and informal (home- and community-based learning) were constantly being crossed. For example, my breeding of black mollies quickly evolved to breeding fancy-tailed guppies and guinea pigs. Once I learned how to predict genetic features using Punnett squares (a square used in genetics to calculate the probability of genotypes and phenotypes among the offspring of a pair), I was fascinated by making predictions about the characteristics of future offspring by learning about dominant traits, tracking genetic histories, and using the Punnett squares.

Imagination is "creating images of the world and seeing connections through time and space by extrapolating from our own experience" (Wenger, p. 173). One activity that distinctly stands out to me during my early teenage years was watching a show called "Quincy, M.E." Each week the medical examiner would solve different mysteries with the help of his pathologist co-worker. Every week, I would imagine myself becoming a pathologist and helping to solve mysteries by studying specimens under a microscope. Using my imagination in this way played a big role in my decision to operate on a dead pregnant molly. I had already watched dozens of autopsy-like procedures on T.V. Why wouldn't I see operating on a dead fish as a "natural" action to take when a dead fish was due to deliver?

Alignment is "coordinating our energy and activities in order to fit within broader structures and contribute to broader enterprises" (Wenger, p. 174). As I was growing up, I was increasingly exposed to the scientific method associated with modern Western science. As my knowledge increased, I was able to align myself more closely with the practices of those actually having membership in the community of practice of modern Western science.

Through this examination of the ways in which learning takes place in our homes, communities, and institutions, it is evident that learning is not an individual process, but a process that is social and cultural. My ideologies about science were not my own unique thoughts; they were formed through a combination of relationships (both real and imagined) with others. Because almost all of my science learning was rooted in modern Western science, it is inconceivable that my scientific methods would have been anything other than belonging to the modern Western scientific worldview.

Sociocultural learning theory can be defined as a perspective that views learning through social interactions (which are situated historically), and that learning is, therefore, shaped by the culture(s) in which the learner is a member. In order for science education to be equitable, it must take into consideration the sociocultural aspects of all students. Therefore, this dissertation focuses on the ways in which a secondary science (chemistry) course acknowledges and incorporates the FofK (Moll, 1992) of the students in a diverse secondary science classroom, the knowledge that students bring to the classroom from their homes/communities. For example, if a teacher had been aware of my concern that my first pet may have been killed by mothballs, s/he could have connected the experience to lessons in ecology, biology, and chemistry. In an ecology lesson, this could have been approached by looking at how chemicals and animals interact. Which chemicals are helpful and which are harmful to animals? Which animals are affected? If a chemical is poisonous to a fish, is it also poisonous to a human? In a biology lesson, we could have compared the respiratory system of fish with that of humans, or the dead fish story could have been used as an introduction to a study of the immune system. In chemistry, we could have identified the elements in a mothball to see why those elements repel moths and whether they are poisonous. If they are poisonous, what makes them so? In an advanced biology class, we could have studied the effects of mothball elements on various systems of humans and other species.

Critical aspects of this research.

While my research stemmed from sociocultural theory, I felt it was important to also use critical theories to help demonstrate the importance of reforming education to be more equitable for all learners. Critical theorists "question the assumption that societies such as the United States, Canada, Australia, New Zealand, and nations in the European Union, for example, are unproblematically democratic and free" (Kincheloe & McLaren, 2005). When applied in the classroom, this theory does away with a top-down curriculum in which teachers are the "holders of knowledge" and restructures it so that students are active participants in the construction of knowledge based on issues of importance to them.

Although my research is not critical in all aspects, it drew from critical theory.

1. The part of my literature review that discusses the culture of science in the secondary classroom highlights the ways in which science education is not culturally neutral. The science curriculums used in the United States (as well as Canada, Australia, New Zealand, and nations in the European Union) are filled with cultural perspectives and assumptions that create a disadvantage for some students. I drew from critical theory when I wrote about literature that shows that the culture of science/science education is, in itself, culturally biased.
2. This research was collaborative between the teacher and the researcher (me). We were able to develop a relationship in which we openly critiqued each other and then reflected on those critiques. By creating an environment in which we were both given the power to question the practices of the other and to discuss potentially different perspectives on data, a multi-faceted inquiry emerged (see Methodology).
3. Finally, my SCFoK approach is, in some ways, a form of critical pedagogy. Earlier I stated that critical pedagogy replaces a top-down curriculum in which teachers are the "holders of knowledge" and restructures it so that students are active participants in the construction of knowledge based on issues of importance to them. By allowing students to share their knowledge, from their own sociocultural backgrounds, students were given some of the power that in a traditional classroom is held only by the teacher. However, this approach does not

advocate that students play an active role in determining what the curriculum is—only in the ways in which meaning is made of the science content. This is because the secondary science curriculum is set in a way that science teachers have very little choice in deciding what the curriculum is. Provided teachers are not in a district that subscribes to a scripted curriculum, however, they do have some flexibility in how the content is presented. This flexibility allows for teachers to use a SCFoK approach.

Purpose of Mixing Paradigms.

While I view the world from a paradigm that is sociocultural, it is not critical in all aspects, nor is it critical throughout. Unlike Lewis and Moje (2007) who refer to their work as "critical sociocultural theory" because they address issues of identity, agency, and power, in the production of knowledge (p. 3), I chose not to use this term. My reasons for not defining my research as critical sociocultural are: 1) I believe identity issues have been well-addressed through sociocultural theory; 2) I used critical theories to address issues of power, but critical theories were used only in portions of my research; and 3) I intentionally minimized the use of critical theories due to their deficit-oriented nature. Critical theories focus on the ways in which nonmainstream students experience inequality in education due to their worldview, style, language skills, and/or stereotypes which differ from the so-called mainstream. I wanted this project to be focused more on the strengths diverse students brought to the classroom rather than on the ways in which they were disadvantaged. Yet, at the same time, it is important to understand the reasons why many students are at a disadvantage in the secondary science classroom. Therefore, my research is more nuanced than to say that it is rooted in critical sociocultural theory. I consider this study to be sociocultural and, in some respects, critical.

To state my research paradigm more succinctly, I think of myself as a sociocultural theorist; however, I recognize the strengths of critical theory and use it in ways that I feel improve our understanding of how students from diverse backgrounds may struggle to engage with the secondary science curriculum. I implement critical theory in a limited way so that its deficit-oriented nature does not overshadow the positive aspects of having a diverse science classroom which therefore possesses a diverse spectrum of FofK.

Ethics

There are two major ethical considerations I had in doing this research. The first regarded the ethical treatment of the teacher involved in this research. The second is the ethical responsibility I have to my readers and those who may use this research to inform their own.

One of the reasons that I chose this particular teacher to conduct a collaborative ethnographic study with is that while observing a teacher candidate whom I supervise, I noticed that some of her students were expressive about her being what they considered a "good" teacher. The students in the class generally treated her with a high level of respect, and there were many students who appeared to be engaged when she was leading the class. When I compared the level of engagement in this teacher's classes with other teachers' classes I observed, her students appeared to be far more engaged. In addition, there was less time spent on correcting student behavior than in other classes I have observed. I began this section by highlighting these reasons for choosing Dana for this research. It is important to point out that before I began the research project, I expected there to be many valuable, positive strategies and techniques that Dana used with her students that would help inform those of us interested in learning about ways in which teachers can help students identify with science content. I have presented this project as being a collaborative effort that focused on teaching science to diverse student populations. My framing the project as a collaboration implies that I value her teaching and her input. In addition, "[qualitative] researchers are guests in the private spaces of the world" (Stake, 2005, p. 459). Even though my research involved a public school classroom, it was also a space created by the teacher for herself and her students--she was under no obligation to give me access to her space.

The teacher's response was important. I needed to make sure that her voice was being heard and if there was a disagreement between us, that I diligently and accurately expressed her view. This was important from the perspective of creating an ethical relationship with Dana as well as making sure that I provide readers with more than one way of looking at the data when Dana and I saw things differently. Using this method provides more validation of the data analysis when Dana's perspective was in agreement with my analysis. This leads to the discussion of the next ethical consideration.

The second ethical consideration is related to the first, but comes from a different perspective. In the same way that I had an ethical obligation to Dana who collaborated with me and allowed me to come into her "space" and write an ethnographical account of what I saw, I also have an obligation to my readers. By providing a four-step analysis that includes the teacher's reaction to my initial analysis, the reader is able to go on a journey of observation with me as I conducted the research. Readers may come to the same conclusion as I or they may conclude differently, but they will have sufficient information to be able to make their own judgments. In this way, the reading audience of this dissertation will become yet another layer of analysis as you, the reader, add your perspective to ours. I hope that readers will share feedback with me in order that those of us passionate about education can work together through conversation toward building an equitable learning environment.

Conclusion

Now that I have discussed some of my personal experiences with science education and how those experiences situated me in the field of science and I have compared that with an example from another science student who shared a different perspective, I have begun to scratch at the surface of what it means to apply sociocultural theory to secondary science education. This dissertation project continued my inquiry into how we can better apply sociocultural learning theory to connect students' identities with secondary science content. The chapter that follows reviews the literature on: 1) equity issues in education—especially science education, 2) science pedagogy for diverse learners, and 3) the history and previous applications of FofK. After reviewing this literature, I will discuss my proposed methodology and research design. My hope is that this research project will continue, as well as broaden, the discussion of applying sociocultural learning theory to science education in order that science education can be more equitable, and that teachers and students will think of school more as a place where people learn from one another.

Chapter 2: Literature Review

In the Introduction, I discussed sociocultural theories of learning and how they pertain to this research. This chapter builds on that discussion through a review of the current literature on inequality in education, science pedagogy for diverse learners, and Funds of Knowledge (FofK).

Inequality in Secondary Science Education

Much research has been done in order to understand why many linguistic, ethnic, and cultural minority students are less likely to succeed academically. This section of the literature review identifies the main cultural factors that impact "nonmainstream" students' educational experiences and opportunities. When using the term "nonmainstream," I am referring to students who come from ethnic, cultural, and linguistic backgrounds that do not belong to the Anglo, middle-class society that is dominant in American culture. Conversely, the term "mainstream" is used to refer to the society that is dominant in our society, and thus, in our schools. While these factors affect many non-mainstream students, they do not affect all. This section will also discuss ways in which some non-mainstream students are affected differently than others.

Below, each main cultural factor is discussed individually in its own section. The main factors are: stereotypes, cultural and social capital, cultural mismatch, language, cultural hegemony, and the student response to these cultural factors. Some cultural factors have many aspects from which they can be discussed. Therefore, some sections are subdivided based on the mechanisms through which the cultural factor is applied. For example, cultural mismatch occurs through the curriculum that is used in the classroom, the teachers who instruct the class, the textbooks that are available to students, and the ways in which students are assessed. Each of those mechanisms are addressed separately. Because my research is focused primarily on nonmainstream students in secondary science, I draw from existing literature in the science content area when possible.

Stereotypes.

Stereotypes occur when a person is regarded as embodying or conforming to a particular image or expectation based on the racial or cultural group in which s/he belongs or is believed to belong. There are four main considerations when examining how stereotyping affects nonmainstream students in secondary education. They are the stereotyping effects of: 1) teachers, 2) guidance counselors, 3) mainstream students, and 4) members of the same group (culture or subculture).

Teacher stereotyping effects are especially important because "it is strong, supportive relationships with teachers that makes for the difference between low SES (socio-economic status) [nonmainstream] youth who succeed academically (even in the difficult mathematics and science curriculum) and those who do not" (Borman & Overman, 2004, as quoted in Hanson, 2009, p. 45). When teachers have negative stereotypes of students, lower expectations often result. Having low expectations can lead to a low quality curriculum as is illustrated by Seiler (2001, p. 1001) in her article that focuses on male African-American students and the science achievement gap. She states that the science curriculum at the urban school in which she conducted a critical ethnography had very low expectations of student achievement. She quoted one of the school's leaders as saying,

> The population here is one that often doesn't do well in college simply because they're not prepared for what they need to do in college. A number of them go the first year, but how far they get is another issue. But an awful lot of the youngsters see college as their only option, which I think is as odd as not seeing it as an option at all. But here everybody [the teachers] is under this delusion [that] everybody's gonna go to college. It's nonsense. It doesn't happen (p. 1001).

Seiler describes the learning community at this school as having "very low expectations for student achievement, [being] poorly coordinated and fragmented, and closely [resembling] Haberman's (1993) 'pedagogy of poverty'" (p. 1001).

Hanson (2010), whose research also focuses on African-American students, particularly females, suggests that the stereotype threat may be greater in science content areas due to the elite status of science in comparison to other content areas (p. 51). Furthermore, science has been stereotyped as being a masculine subject (Lemke, 2001), which may create a double stereotype for non-mainstream females who fall outside of the stereotypical scientist by being neither White nor male.

While parents and students may play a role in choosing electives, guidance counselors play a critical role in guiding students to choose college- or vocational-track courses (Bettie, 2003). According to Bettie's research, low-income and Latino students are much more likely to be guided toward vocational rather than college-track courses. Often, students aren't even aware that they are not obtaining the courses they need for college admission until it is too late. While parents may sign the course registration form that the students filled out with their guidance counselor, they may be unaware of the consequences of the class choices. (This relates to the issue of social capital, which is discussed in more detail under the subtitle of "Cultural Hegemony.")

Just as schools use various tracking systems that reify stereotypes as students are systematically grouped into the track in which the dominant mainstream counselors, teachers, and administrators have imagined them to fit, so do the dominant mainstream students. Bettie (2003) describes the ways in which the prep students (predominantly White, upper-class) determine who is and is not elected into the student government. Although the election process seems very democratic, students must already have connections with the members of the association in order to have any real chance of becoming elected. This process further reifies the social construct that White upper-class students, often referred to as preps, are at the top of the social hierarchy of the school and that students who don't look, act, or perform like them are positioned beneath them in school and in life.

What is interesting is the tendency for the nonmainstream students to segregate themselves socially along the constructs made by the mainstream. This is a concept known as "stereotype threat" which takes place when nonmainstream students come to identify the mainstream students as doing well in school and therefore characterize their own identity as one that does not perform well in school. This can be evidenced in the term "acting White" that African-American students frequently label another African American who is achieving high grades (Delpit, 2006). Furthermore, parents and role models are likely to give messages that the school curriculum is "an attempt to impose white culture on them" (Ogbu & Simons, 1998, p. 178)[3]. Nonmainstream groups often

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[3] Further discussion on Ogbu Theory is below in the section titled "Student Response."

have a conflicted frame of reference because they see assimilation to white culture as subtractive to their identity. According to Hanson (2009, p. 51), "[Stereotype] threat might be even greater in science since this is the most elite area of the curriculum." Therefore, in order for nonmainstream students to become well-educated in the sciences, they are likely to have to overcome opposition not only from outside groups, but from their own racial/cultural group.

Bettie (2003) describes the nuances in how stereotypes are manipulated that blur the distinction based on race/ethnicity and those based on SES. She states:

> [The] same set of binaries surface repeatedly: white is middle-class is suburban; black is lower-class is urban. But a slippage occurs in which class references are dropped out, and white stands in for middle where black stands in for lower, or suburban stands in for white and urban for black. Class and racial/ethnic signifiers are melded together in such a way that "authentic" black, and sometimes brown, identity is imagined as lower-class, urban, and often violent—and male as well (pp. 47-48).

However, Bettie (2003) did not focus on Asian American students who are considered to be neither white, nor black, nor brown. "Asian American students have been described as a 'model minority' for their academic achievements, particularly in the natural science and related fields" (Lee, 1997, p. 107). Yet, Lee (1997) explains the difficulty with the stereotyping of Asian American students. First, she explains that there is great diversity among Asians. "The major groups of Asian Americans in the U.S. include: (a) East Asians (i.e., Chinese, Filipino, Japanese, Korean); (b) Pacific Islanders (i.e., Fijian, Guamanian, Hawaiian, Marshall Islander, Melanesian, Samoan, Tahitian, Tongan); (c) Southeast Asians (i.e., Cambodian/Kampuchaen, Hmong, Indonesian, Lao, Malayan, Singaporean, Thai, Vietnamese); and (d) South Asians (i.e., Bangladeshi, Burmese, Asian Indian, Nepali, Pakistani, Sri Lankan)" (p. 109). These groups are culturally very different from one another. Although there is also great ethnic diversity among other groups (i.e., Latin Americans), stereotyping Asian Americans creates a problem due to positive stereotyping. For example, stereotyping Asian students as being academically successful and high achieving creates difficulty for those groups that do not place such an emphasis on academic achievement. For example, some Asian groups identify with Confucianism or Buddhism, which tend to value highly self-determination and personal responsibility whereas other groups, "such as Pacific Islanders, have more relaxed attitudes toward achievement" (Trueba, Cheng, & Ima, 1993, cited in Lee, 1997, p. 109). In addition, some Asian groups have fewer human capital resources than others. In fact, third wave Asian immigrants arriving since the mid-1970s tended to have fewer resources than the Chinese, Japanese, Korean, and Taiwanese immigrants, who comprised the first and second immigration waves between the mid-1800s and the mid-1960s. These third wave immigrants "were largely Southeast Asians from Vietnem, Cambodia, and Loas" (Lee, 1997, p. 110). By stereotyping students of Asian ethnicity as being academically successful or "smart," the needs of some Asian American students have been left unmet. Furthermore, the academic success of seemingly well performing Asian American students comes at a great cost.

> Asian American students often feel pressured to meet the high expectations of their parents and teachers in academic achievement, particularly in mathematics

> and science. A negative consequence of this pressure is that many Asian American students become high achievers with good grades, but passive learners who avoid risk-taking or creative process— the attributes that are important for advancement in scientific and technological fields (Benjamin, 1986; Fallows, 1987; Hirayame, 1989; Rohlen, 1983; White, 1987). Academic pressures often lead to emotional, mental, and socialization problems associated with continuous stress related to high achievement (p. 110).

While stereotyping of Asian Americans tends to take a positive form rather than a negative one, the stereotyping still creates a problem in the science classroom. A teacher who has low expectations of some students due to ethnic or racial stereotypes creates a disadvantage in that students may not be taught science content that is rigorous enough. On the other hand, a teacher who has high expectations of some students due to ethnic or racial stereotypes may be teaching science content that is beyond what the student is capable of processing without causing severe stress. Furthermore, stereotyping based on ethnicity fails to take in account the variability of human intelligence that occurs within every group.

Due to the nuances between race/ethnicity and SES, it is not possible to fully discuss the ways in which culture creates inequality in the secondary classroom without also discussing class. By examining the concept of cultural reproduction (Bourdieu, 1977), it becomes more clear as to how it is possible that mainstream society often ends up having privilege (as reflected in higher levels of education and income as well as higher career positions) while the majority of African Americans, Mexican Americans, and other people of color are more likely to be in blue (or pink) collar positions that pay less. MacLeod (2008, p. 14) summarizes the theory of cultural reproduction as follows:

> First, distinctive cultural capital is transmitted by each social class. Second, the school systematically valorizes upper-class cultural capital and depreciates the cultural capital of the lower classes. Third, differential academic achievement is retranslated back into economic wealth—job market remunerates the superior academic credentials earned mainly by the upper classes. Finally, the school legitimatizes the process "by making social hierarchies and the reproduction of those hierarchies appear to be based upon the hierarchy of 'gifts,' merits, or skills established and ratified by its sanctions, or, in a word, by converting social hierarchies into academic hierarchies"(Bourdieu, 1977, p. 496).

This process of cultural reproduction produces inequality in education both directly and indirectly. It does so directly by encouraging the academic work of students who appear to belong to the upper classes—those who are expected to do well. It does so indirectly through economics. Those families who comprise the "blue" and "pink" collar jobs are less likely to be able to afford private schools or to live in the areas that have the best education systems (suburban, and especially, wealthy suburban neighborhoods) and are more likely to live in poor urban neighborhoods. In effect, people end up segregating themselves based on income—which roughly equates to being segregated based on color. Orfield (2006) breaks down the conditions of this "resegregation" that has occurred throughout the United States. He concludes that segregation matters because "[concentrated] poverty is shorthand for a constellation of inequalities that shape schooling" (p. 29). He asserts that equal dollars do not produce equal results (and, generally, urban school districts have fewer funds than do the wealthy suburbs)! More money is needed to fund schools in areas where poverty is greater because in those areas there is also a concentration of greater need (including language, special education, social work, supervision, new teacher training, and remedial education needs) in order to produce equal results, but those communities are likely to have smaller tax revenues.

Cultural and Social Capital.

The school system essentially belongs to the upper classes and, therefore, values the cultural capital of the upper classes (Macleod, 2008). Students from the upper classes are exposed to many "cultural" experiences such as going to museums, theatre, dance lessons, and so forth, that develop in them the habitus (socially learned dispositions, skills, and ways of acting) that is favored in society and by the school system. Students from a lower SES (socioeconomic status) are likely to have a habitus that inhibits them from being able to navigate the education system, which has been constructed to suit the habitus of the upper classes. Thus, a culture in education is created that strongly values the habitus of students coming from the upper classes while perceiving lower-SES students as lacking skills, having behaviors that are not conducive to learning, or being less smart.

Bourdieu's concepts of cultural capital can be understood by looking at students with college-educated parents. They are in a much better educational position because their parents are aware of the types of courses that must be completed in high school in order to gain admission to college. Students whose parents are not college educated are much more likely to think that graduating from high school is the only prerequisite for getting admitted to college. When Bettie (2003) interviewed a Mexican student who was accidentally tracked upward about the differences between her parents and the parents of her mainstream peers, she said: “Well, they [her parents] can’t help me with my homework, ‘cause I’m way ahead of them. And they didn’t know anything about college applications, SATs, or college-prep courses. They didn’t know the difference between the university and a junior college” (p. 82). Students whose parents aren’t college educated are less likely to have the information they need to navigate the system in preparation for college.

Parental help in navigating the education system is just one way in which parents provide social capital to support their children’s education. Brewster & Bowen, (2004) identify “at least four types of parental social capital, including parent-child discussion related to education, parental involvement in the parent-teacher organization, parental monitoring of children’s behavior, and direct parental involvement in children’s educational practices” (p. 47).

Cultural capital also helps explain why some Asian American students perform so well academically. Ogbu (1992) states that in addition to having high expectations, many Asian American parents provide educational opportunities for their children even when it creates a financial or personal burden. “Many enroll their children in special summer programs, field trips, enrichment programs, science fair competitions, and prestigious academies in mathematics and science (e.g., Westinghouse Awards)” (cited in Lee, 1997, p. 112). By having parents who strive to provide every academic advantage possible to their children, many Asian parents are able to create an environment, like that of Bill Gates, where their children have access to the resources they need to learn and are given the time to devote themselves to learning. The academic achievement of students afforded opportunities such as those mentioned above are likely to be much greater than the academic accomplishments of children who are expected to earn money to help support the family or who are given the responsibility of caring for younger siblings while parents work. And while students who work may be gaining valuable work experience, this experience is not highly valued or drawn on in school.

Cultural Mismatch.

An issue that has been of central concern to sociocultural scholars is the way in which students "from nondominant backgrounds negotiate the discontinuities and tensions between their home and school lives" (Lewis, Enciso, & Moje, 2007, p. 124). When students come from a background in which they need to make these types of negotiations in order to learn in the school setting, there exists a cultural mismatch. Four significant mechanisms through which a student can be affected by cultural mismatch are: 1) teachers, 2) curriculum, 3) textbooks, and 4) assessments.

While the nation's student population has been becoming increasingly diverse, the teacher population is increasingly White and female (Jorgenson, 2000, cited in Lee & Luykx, 2006). In 2007-2008, 83.5 percent of secondary school teachers were White, non-Hispanic and 59.3 percent were female (NCES, 2009). Meanwhile, only 54.1 percent of public elementary and secondary school students are White (NCES, 2011). In Maryland, where the diversity is higher than the national average, only 45.5 percent of students are White (NCES, 2011). "Given the increasing student diversity even within individual classrooms, matching teachers with students of similar background is often not feasible" (Lee et al., 2006, p. 103). However, it is important that teachers be aware of the ways in which students' cultures may impact their learning of academic content.

To illustrate how cultural mismatch can create an academic disadvantage for nonmainstream students, I will discuss the cultural norms of science, including the secondary science curriculum, in the United States and demonstrate how this curriculum may be incongruent with the cultures of nonmainstream students.

Science in U.S. public schools places an emphasis on independent thinking (Lee & Luykx, 2006) by calling on students individually and assessing them using written tests to be completed independently. Students coming from nonmainstream backgrounds, however, may be accustomed to a more collectivistic approach to solving problems. Not only would it benefit nonmainstream students to have less focus on tasks that are completed independently, it may be beneficial to all students. LeFevre (1987) argues that by teaching students to work independently and to compete with one another for grades or other compensation for their ideas, "they may fail to take advantage of the synergy that can arise from social interactions" (p. 26). It is also important to note that recently, best practices in science education have called for more collaborative work among students (NSES, 1996).

Another way in which cultural mismatch can be observed concerns the Western cultural perception of what constitutes science. "[The] problem is that there is no perfect account of science that clearly represents all of science, past and present, and just as clearly eliminates all endeavors that scientists do not consider to be science. In the final analysis a human judgment must be made" (Cobern & Loving, 2000). Although the U.S. mainstream worldview perceives science to be entirely rational and objective, rhetoricians and philosophers of science "emphasize science as a social enterprise in which knowledge evolves by means of argument in a community that accepts or rejects certain problems, concepts, procedures, and kinds of evidence….Whether or not something is accepted as scientific 'truth' has a great deal to do with how its case is argued in the community of scientists" (Lefevre, 1987, p. 87). In the U.S., the scientific community has received beliefs that affect whether they accept or reject new ideas. "It is not enough to say that we use language to constitute reality; it is equally important to say that we do this *together*, in a culture, and that culture, by its creations, can influence future thought" (p. 114).

> Observations of the natural world are always filtered through our perceptual apparatus and/or intricate instrumentation, interpreted for within elaborate theoretical frameworks, and almost always mediated by a host of assumptions that underlie the functioning of 'scientific' instruments…. Science, contrary to common belief, is not a lifeless, completely rational, and orderly activity. Science involves the invention of explanations and theoretical entities, which requires a great deal of creativity on the part of scientists. The 'leap' from atomic spectral lines to Bohr's model of the atom, with its inferential nature, entails that scientific entities, such as atoms and species, are functional theoretical models rather than faithful copies of 'reality'" (Abd-El-Khalick, Lederman, Bell, & Schwartz, 2002, pp. 500-501).

Science is practiced within a culture and scientists are a product of that culture. Therefore, science is affected by cultural elements such as social fabric, power structures, politics, socioeconomic factors, philosophy, and religion (Abd-El-Khalick, et al., 2001). These arguments against a Western (positivist) view of science and their counter arguments are known as the science wars which began with C.P. Snow's *The Two Cultures* (1960).

The real problem, argue Cobern et al. (2000), is not that other (non-standard) worldviews be counted as science; rather the problem is scientism—the cultural hegemony of science. "The problem is not that science dominates at what it does best: the production of highly efficacious naturalistic understanding of natural phenomena. The problem is that too often science is used to dominate the public square as if all other discourses were of lesser value" (Cobern et al., 2000). Rather than focus on what should be counted as science, those involved in science education should recognize that "the learning environment of the science classroom can be improved, especially with regard to students who typically do not do well or who do not like science, if the teacher is more aware of student world views as related to science" (Cobern, Gibson, & Underwood, 1995).

Lemke (2001) promotes teaching non-European worldviews of science to more effectively teach the students in today's American classrooms. He states that "science education is increasingly a global enterprise, and even in one country, students today more and more often come from diverse cultural backgrounds" (p. 300). He asserts that science education must be revamped to take into account sociocultural theory which proposes that people use "tools" that are derived from the social organizations and institutions created by their culture to make sense of their environment. These tools include: "languages, pictorial conventions, belief systems, value systems, and specialized discourses and practices" (p. 296).

According to Lemke (2001), the U.S. education system teaches science in a way that is disconnected from non-Eurocentric cultural beliefs and values. It is, therefore, ineffective among students who do not have masculine, middle-class, European identities that fluently use prestigious varieties of English. He warns that it is not just the language of science that must change, but the entire makeup of science learning which comprises a synthesis of "linguistic, mathematical, and visual representations" (p. 298). Lemke observes:

> Unfortunately, few studies have yet attempted to incorporate viewpoints that range across the full spectrum of social and cultural differences to be found in science education today. We preach collaboration across differences as an exemplary way for students to study science, but we do not often enough practice it ourselves as a way to study science education (p. 305).

Lemke (2001) points out that science education research is necessary to determine the relationships between students' home and school cultures. In addition, he argues, that because students have diverse ways of understanding everyday phenomena, "our curricula must work to ensure greater continuity in students' ways of experiencing as they move from one classroom to another and from classroom to hallway and to neighborhood to home" (p. 310). In addition, Lee (2005), a distinguished scholar in teaching science to non-native speakers, asserts that students who have cultural beliefs that are discontinuous with Western science should be instructed in a manner that enables them to cross cultural borders between the two domains (p. 503). While the science wars continue with no definitive winner, one thing is clear: there is substantial literature that supports including diverse worldviews in the science classroom.

"Many students do not share teachers' predominantly middle-class, North European values about individual effort and achievement, attention to detail, the separation of reason and emotion, respect for authority, following instructions exactly, and so on." (Lemke, 1990, pp. 177-178). When this occurs, students may not identify with the science they are being taught. This is especially true if "it is presented as the monopoly of people do share these values" (Lemke, 1990).

Although being White and middle-class does not make a teacher ineffective in working with nonmainstream students, it is important for teachers to be aware of other learning styles and ways of thinking about science that may be common among students coming from other cultural backgrounds. For example, Rosenthal (1996) states that it is important for African-American students to be taught math and science in a manner which incorporates "cooperative, practical, laboratory, and applied learning with materials presented in *multiple ways* and *limited time constraints"* (emphasis mine)(p. 49). Sadly, rather than receiving helpful professional development, teacher candidates are often told that children coming from different cultures are "mismatched to the school setting and therefore cannot be expected to achieve as well as White, middle-class children" (Delpit, 2006, p. 178). When a school lacks racial and cultural diversity among its teachers, it also poses a problem of not having role models or mentors in which nonmainstream students can relate. In addition, lack of teacher diversity creates a "chilly climate for African American women [as well as other nonmainstream students] in science" who lack role models and mentors with whom they self identify (p. 50).

Another way in which cultural mismatch takes place is through textbooks (as well as other printed material). Hanson (2009) asked young women about their experiences in the science class and with science textbooks. Here are some of their responses:

- "Sometimes I do feel out of place…I see only white scientists in my textbooks and in the films we watch."
- "Our school is 85% [minority] and there is still no black man or woman to look at in these books. I feel not so free."
- "There's not enough recognized female scientists in high school study books. I don't recall any study of female scientists when I was in high school. I only remember male scientists and inventors. Even though, there are plenty of [women] working or studying science I believe that men are mostly recognized" (p. 61).

In addition to the problem of assessments generally being an individual task (discussed above under the subheading "Curriculum"), there are other ways in which assessments can create inequality through cultural mismatch. One problem occurs when an assessment is created that is biased due to language that may be construed differently based on culture and/or language (this will be discussed in more detail below under the subheading "Language"). In addition, assessments have fairness issues when they are written in ways that are "sexist, ethnically insensitive, stereotypic, or otherwise offensive to subgroups of the population" (Bond, Moss, & Carr, 1996, p. 121 as cited in Penfield & Lee, 2010, p. 15). This may happen without the test developer being aware that some students are affected by the way in which the assessment was worded. For example, "ELL students are seldom assessed in their home language, low-income students confront test items that are unrelated to their daily lives, and knowledge of the cultural conventions shaping academic discourse is assumed more often than it is taught" (Lee & Luykx, 2006, p. 151).

Whether cultural mismatch occurs unintentionally or not, the consequences of having an education system that helps some students much more so than others has an effect of preventing many students from reaching their full academic potential.

Language.

Whether students come from a non-English speaking background or one that speaks a non-standard variety of English, their ability to learn academic content is likely to be affected. Language considerations include both how English-only curriculum impacts ELLs as well as implications for speakers of nonstandard varieties of English (such as some African-American and Mexican-American students).

"English only" policies in education create inequality in science education for ELL students in the following ways:

- they require ELLs to learn new academic content in a language in which they are not proficient;
- they often are enrolled in ESOL or sheltered science courses which may offer less opportunity to learn science content since more attention is being focused on language instruction; and
- they may not have acquired academic English proficiency when they are determined to be proficient in English due to their conversational English ability (Lee et al., 2006).

Conversational English, also known as Basic Interpersonal Communication Skills (BICS), is the type of language used for communicating socially. Cognitive Academic Language Proficiency (CALP) is for understanding and producing academic content. According to Cummins, BICS takes from six months to two years to develop, but CALP generally takes from five to seven years and can take as many as nine years to develop if the student hasn't had prior schooling or has had little support in native language development (Cummins, 1981; Thomas & Collier, 2002). Gee states that one of the reasons CALP is particularly difficult to grasp in science is that it differs greatly from the grammatical patterns found in BICS (cf. Rosebery & Warren, 2008). In addition, science is laden with science-specific vocabulary and terms that are used differently in science than in other subjects. For example, in a biology class, a student who received special education services, once looked up from his worksheet where he needed to analyze the metabolic effects of different concentrations of a substance. He said to me, "Concentration, I know that word from English. It means to focus, right?"

Although assessments mandated by NCLB (No Child Left Behind) are intended to close the achievement gap between mainstream and nonmainstream students, they are also another mechanism through which ELLs experience inequality (Penfield & Lee, 2010). There are four important reasons why outcomes for ELLs are lower on science assessments:

1. According to the National Research Council (1999), "if a student is not proficient in the language of the test, her performance is likely to be affected by construct-irrelevant variance—that is, her test score is likely to underestimate her knowledge of the subject matter being tested" (Penfield, 2010, p. 11)

2. "A component of fairness for any assessment of content mastery is that the student has had adequate opportunity to learn the material being tested and to be successful in meeting the relevant academic standards as measured by the test" (Penfield et al., 2010, p. 2).
3. Lee (2006) states that it is difficult to ensure that science assessments to be taken by nonmainstream students have been developed in a way that they are valid and equitable (Lee et al., 2006, p.99). And
4. Solano-Flores and Nelson-Barber (2001) identify five areas in which science assessments can be improved by considering cultural validity. They are:
    - student epistemology
    - student language proficiency
    - cultural worldviews
    - cultural communication and socialization styles, and
    - student life context and values (cited by Lee & Buxton, 2010).

Even if these areas have been identified, Lee and her colleagues point out the difficulty a teacher has in actually creating an assessment that considers all of these criteria for each of her students. Standardized tests, that are developed without taking into account individualized student populations have great challenges in terms of validity.

In addition to the ways in which language can adversely affect ELLs in secondary (science) education, the language variety used in the classroom can also create inequality among other groups of nonmainstream students who are not ELLs. For example, Lisa Delpit (2006) discusses the discourse styles of African-American students who often produce longer, more complex narratives than Anglo-Americans. Rather than focusing on one topic, as the stories of Anglo-American students typically do, the narrative may shift scenes. After listening to a teacher retell a story told by an African-American student, Anglo-American adults generally reported that it was incoherent and may be a sign of language, learning, or family problems. Interestingly, when African-American adults listened to the same narrative, they stated that the narrative was "well formed, easy to understand, and interesting, with lots of detail and description" (p. 55). Clearly, discourse is perceived differently depending on the cultural background of the listener. In a nation where the majority of teachers are Anglo-American, non-Anglo-American students are much more likely to be perceived as having language deficiencies.

Non-verbal communication is another area of language that can create an unequal learning environment for nonmainstream students. Elmesky and Seiler (2007), in their study of African-American students taking a secondary science course, found that student movement expressiveness was actually a resource that teachers could use to enhance classroom learning. Unfortunately, these movements are often viewed as being off-task, nonproductive, and resistant rather than being used to help students learn.

Cultural Hegemony.

Cultural mismatch, (standardized) English language policy, racial/cultural stereotyping, and cultural and social capital are all factors that produce cultural hegemony; however, so far I have discussed fairly subtle ways in which racial and cultural inequality in education occurs. Also important are various not-so-subtle examples, that have not yet been addressed, which illustrate how students from nonmainstream backgrounds receive unequal education in comparision to mainstream students.

The percentage of students who graduated from U.S. schools after attending four years of high school (average freshman graduation rate [AFGR]) was 75.5 percent for the 2008-09 school year. The actual AFGR, however, varies greatly from one racial/ethnic group to another. During the same 2008-09 school year, 91.8 percent of students coming from an Asian/ Pacific Islander ethnicity and 82 percent of Whites graduated in 4 years. The percentages are much lower for other groups such as: Hispanics who had an AFGR of 65.9 percent, American Indians or Alaska Natives who had an AFGR of 64.8 percent, and Blacks who had an AFGR of only 63.5 percent (U.S. Department of Education, 2011). Orfield (2004) blames part of this problem on NCLB because it created a system in which "a school or school district can be honored and praised for raising its test scores even when it is pushing low-achieving students out of school in order to raise average test scores" (p. 4).

Angela Valenzuela's research with Mexican immigrants and Mexican Americans in the public school system in Houston, Texas, discusses "subtractive schooling" (1999), which is like cultural mismatch in that it disadvantages students coming from nonmainstream backgrounds; however, her work places the blame for student underachievement squarely on the education system. Valenzuela believes that both the high-school teachers and the curriculum, at the inner city school where she did research, were aimed at "mainstreaming them into the dominant society by subtracting their community-based language and culture" (p. xvi). In the forward to *Subtractive Schooling: U.S.-Mexican Youth and the Politics of Caring*, Christine Sleeter states:

> Schools are an instrument of the maintenance of colonial relationships in that they constitute an arm of the state through which belief systems and cultural

> relationships are taught…I do not believe that most Anglo teachers see themselves as colonizers, and that most do care about the students they work with. At the same time, most Anglo teachers do not view racial and ethnic relationships within a political perspective, and take for granted beliefs in the superiority of U.S. society, predominance of European and Euro-American culture, and the pragmatic utility of fluency in English only (p. xvii).

A good example of this comes from Bettie's (2003) research where she observes an American government teacher telling students (a heterogeneous group including Mexican, Mexican-American, and Anglo-American students) an ethnocentric account of early American history by making statements such as: "as far as our country starting out and everything," and "Later we won Mexico" (p. 177). These types of statements subtract the identity of students whose cultural heritage did not start out in the United States and did not win Mexico because the teacher's statements make it very clear that their identity is invisible to him as he addresses the class (Valenzuela, 1999). In addition, McDermott, Shelton and Mogge (2002), found that the majority of preservice teachers entering the field had negative attitutdes and bias towards immigrants of color, specifically Mexicans. The words most commonly associated with immigrants of color were "dirty" and "smelly." According to Gay (2000), these prejudices and practices can cause irreversible damages to nonmainstream students' intellectual development and academic achievement.

Student Response to These Cultural Factors.

As a result of subtractive schooling practices, first- and second-generation Mexican immigrants often outperform third- and later-generations as they reach an "invisible ceiling of blocked opportunity" (p. 4). Ogbu (1987) postulates that first and second generation Mexican immigrants perform better due to their voluntary minority status. Voluntary minorities tend to believe in "The American Dream" of "making it," but after generations have passed and third- and successive-generations haven't made it, the "Dream" is no longer believed in for themselves and others like them. This is not the case for all immigrant groups, however. Some examples of ethnic groups that tend to be successful in the U.S. are Cubans, Chinese, Europeans, Indians, Japanese, and Koreans (Ogbu et al., 1998). Ogbu refers to these groups as "voluntary minorities" and attributes their success to the fact that they came to the U.S. voluntarily in order to have more opportunity than in their native country.Involuntary minorities, due to the nature of their history, subordination, and exploitation, are more likely to encounter less success. In addition, they may also be inhibited from acquiring English due to a fear of losing their identity (164).

Due to the barriers discussed above, some nonmainstream groups do not believe they can achieve the "American Dream." As presented in Ogbu's Theory, many people have arrived at the conclusion that the folklore concept of "making it" (that is—hard work and good grades equate to being successful in life), for them, does not apply. These groups have a conflicted frame of reference because they see assimilation to White culture as subtractive to their identity. Recently, the term "acting White" has been termed "stereotype threat" by academic scholars (Delpit, 2006; Hanson, 2009). Rather than become "White," many choose to oppose "Whiteness" even though this stance is in many ways self-defeating. Furthermore, these students are more likely to have role models that do not hold higher academic degrees, but are successful financially due to athletics, acting, singing, gang leading, and/or drug dealing abilities. Parents and role models are likely to give messages that the school curriculum is "an attempt to impose white culture on them" (Ogbu et al., 1998, p. 178).

Conclusion.

That nonmainstream students are at a disadvantage when it comes to education in the United States cannot be denied. In order to create an education system that is equitable, it is important to study ways in which diverse students identify with academic content. Furthermore, it is also important to identify ways to create more equitable classes and classroom instructional experiences.

Science Pedagogy for Diverse Learners

While Funds of Knowledge (FofK) has been effective with other content areas, it hasn't been applied much to the science content area nor has it been used in settings where the student population is diverse. Research that has focused on science pedagogy for diverse learners include: Cognitively Based Science Instruction (Warren & Rosebery, 1995, 1996); and Instructional Congruence (Lee & Avalos, 1998). Each of these is discussed further below. Because my research involves using a modified version of FofK, I also include a discussion of the ways in which each of these approaches or projects is similar to and different from FofK.

Cognitively Based Science Instruction.

Warren and Rosebery (1995) developed the Chèche Konnen Project based on a cognitive science perspective. This perspective proposes that teachers need to recognize the developed forms of reasoning and problem solving that students experience in their everyday lives (Lee & Buxton, 2010) and bring these into their science instruction. With a focus on students who come from non-dominant communities, the project's "approach to research, development and design builds on ongoing analysis of intersections between the heterogeneity of meaning-making practices in the sciences or other academic disciplines and the heterogeneity of meaning-making practices in which students routinely engage as they navigate life" (Chèche Konnen Center, 2010) If students' out-of-school experiences are recognized as being valuable to the learning that takes place in the science classroom, then teachers will build connections between students' experiences and scientific knowledge and practices. Although scientific practice in school is not exactly the same as scientific practice in professional communities, this project is built on the premise that school science should be related to science as it is practiced in professional science communities (Lee et al., 2010). In Chèche Konnen, the course of inquiry grows out of the students' beliefs, observations, and questions rather than being predetermined by a set curriculum. This project focuses primarily on the role of students' first language in scientific sense making (Lee & Luykx, 2006). An example of Cognitively Based Science Instruction follows:

> Ballenger (1997) described how a fifth-grade Haitian boy, who was learning English as a new language and considered a special education student, used both Haitian Creole and English to understand metamorphosis as a particular kind of change in biology. Speaking in Haitian Creole and using Haitian Creole syntax, the student differentiated the meanings of two terms, *grow* (referring to continuous change) and *develop* (referring to reliability patterned transformation from one discrete stage to the next). Then, the student switched into English and

used the terms *grow* and *develop* to further enhance his understanding of these two aspects of change (Lee et al., 2010, p. 64).

Cognitively Based Science Instruction is similar to FofK in that it focuses on the value of students' cultures; however, Cognitively Based Science Instruction is primarily concerned with the connection the students make with their native *language,* whereas FofK deals with the *knowledge* students bring from their native culture.

Instructional Congruence.

Since the early 1990's, Lee and colleagues have conducted research that has focused on cultural congruence through the framework of instructional congruence (Lee et al., 2010). This framework "emphasizes the role of instruction, as teachers (or educational interventions) explore the relationship between academic disciplines and students' cultural and linguistic knowledge and devise ways to link the two…. For students who are not from the culture of power, teachers need to provide explicit instruction about that culture's rules and norms for classroom behavior and achievement" (Lee et al., 2006, p. 76). Especially when there are discontinuous elements between the students' home culture and the culture of the science classroom, teachers need to provide explicit instruction to help students bridge the competing sets of values and practices (Lee et al., 2010)(cf. Delpit, 2006, but not in science).

Parsons (2008) focused on eighth-grade science achievement by examining African-American students in relation to three dimensions of Black Cultural Ethos (BCE)—social perspective of time, verve, and rhythmic-movement expressiveness. Parsons found that students who received intervention based on an instructional congruence framework improved academically. What the intervention entailed was the teacher providing a short reading and discussions on BCE and three consecutive lessons on force that featured the three dimensions of BCE being investigated (Lee et al., 2010).

Instructional Congruence is similar to in the way that it encourages teachers to link the students' home culture with the learning that takes place in the classroom. However, Instructional Congruence differs from FofK in emphasizing the need for teachers to "provide explicit instruction about rules and norms for classroom behavior and academic achievement" (Lee et al., 2010, p.67). Therefore, with Instruction Congruence there is a focus on teachers providing students with cultural capital, whereas with FofK, the cultural capital moves the other way—students bring their cultural capital into the classroom where it can benefit other learners.

Funds of Knowledge

As discussed in Chapter 1, meaning, practice, community, and identity must be integrated when characterizing social participation as a process of learning and knowing (Etienne Wenger, 1998). When socio-cultural learning theory (SCLT) is applied to the science classroom, students who engage in science are acquiring certain identities that are related to who they are and who they want to be" (Barton & Tan, 2008, p. 51). One way to apply SCLT to the science classroom is through using a FofK approach. FofK is founded on the "idea that every household is, in a very real sense, an educational setting in which the major function is to transmit knowledge that enhances the survival of its dependents (Moll, 1990). Gonzalez, Moll, and Amanti (2005) and Moll (1992) focused on the communication crisis that amplifies the education crisis in the U.S., where Mexican students' learning needs are not being met because the teaching methods cater to the American mainstream. Gonzalez et al. (2005) describe an approach that empowers middle-school students by enabling them to use their FofK—that is "historically accumulated and culturally developed bodies of knowledge and skills essential for household or individual functioning and well-being" (Moll et al., 1992, p. 133) as a basis for learning. The researchers draw on Vèlez-Ibàñez's anthropological analysis of networks of exchange among Mexican-origin populations as a basis for the FofK Methodology. Vèlez-Ibàñez (1983) claimed that *confianza en confianza*, trust in mutual trust, is foundational among Mexican community networks. This trust can be established by taking a sincere interest in the participants' everyday lives. Gonzalez (2005) found that "the more that participants can engage and identify with the topic matter, the more interest and motivation they will have" (p. 9). Because the students' FofK were different from that of the teachers, teachers also became learners as students and their families taught them about their lives. "What each person brings to the context is valued as one more piece to the puzzle of how to ensure academic success for all our students" (p. 20). This type of approach creates a non-judgmental environment where students are safe to synthesize their FofK with their new hypotheses as they gather new information (p. 20). Thus, students are encouraged to develop their identities as they practice science concepts by building upon the FofK they have acquired through their homes and their communities.

Basu and Barton (2005) show how students' identities develop as they practice science when students' FofK are connected to the classroom. In their study, minority students from low-income families participated in an after-school science program. Their study explored the relationship between FofK and a sustained interest in science. In this study, "sustained interest" is defined as students who "complete more than the task at hand in the classroom" (p. 468). Basu et. al (2005) found that " a strong connection existed between a sustained interest in science and authentic opportunities for students to develop skills that advanced them toward their visions of their own futures, which includes both personal and professional desires" (p. 479). One of the examples they give is a student who wants to become a cartoon artist. They found that he valued science when it 1) enabled him to further develop ideas for his cartoons and 2) helped him to create realistic cartoon characters. For instance, he was able to use what her learned about "the possible melting of the polar ice caps due to the ozone hole [to] develop 'a character that comes from water… and takes over the planet'" (p.479). When the researchers visited the neighborhood where the student lived, they noticed the value of art to the community. Several forms of artwork were present such as works of intricately detailed graffiti on buildings and subway platforms. This example illustrates a connection between a student's FofK and a sustained interest in science (p.480). Basu et. al (2005) also found that there was "a strong connection between a sustained interest in science and science learning environments in which students were able to cultivate relationships with people and in ways that reflected their values of relationships and community" (p. 483). They gave as an example a vignette of a student who had an interest in making a variety of candy bars. Her "story shows how the students in our study valued science because it allowed them to work in groups—to cultivate and maintain friendships while doing science" (p. 483). Finally, Basu et. al found that "science activities supported students' sense of agency for enacting their views on the purpose of science (p. 466). Gonzalez and Moll (2002), explain that "FofK are *practice*—they are the cultural knowledge an individual possesses as well as *how and why they act* upon that knowledge" (in Basu et. al, 2005). For example, Basu et al. discuss a student who envisioned building a robot that could help him to perform tasks such as cooking and doing homework. This student did not aspire to become a scientist because he felt that scientists were very intelligent. Rather, he simply viewed himself as using science. Basu et. al (2005) found that "[when] students encountered science classrooms in which they could choose and engage in activities connected to their visions of the future, how they valued relationships, and their definitions of science, they developed a strong, long-term commitment to pursuing science" (p. 487).

Moll and Greenberg (1990) claim that "by developing social networks that connect classrooms to outside resources, by mobilizing FofK, we can transform classrooms into more advanced contexts for teaching and learning" (p. 344). Indeed, we can. I believe FofK can be modified to nurture a Community of Practice (CoP) (Lave & Wenger, 1991) –or, in this case, a community of learning. Thus far, FoK research has been centered on primarily Latino classrooms rather than diverse classrooms. However, recently FofK research has been expanding to other populations. By making FofK student-centered—that is, by having students bring their FofK to the classroom to share with others rather than sending teachers into the community to learn about students' knowledge—the diverse classroom can become a CoP.

Student-Centered Funds of Knowledge.

Moll's FofK Approach is excellent and offers a much more equal learning environment for Mexican students in the U.S. Gonzalez et al. (2005) spent countless hours in the field learning about the practices and knowledge of Mexican communities to which many of their students belonged. The research was extremely intensive and possible because one ethnic group was being studied. In regions where the population is more diverse, the original FofK Approach can be made into a student-centered approach to accommodate the wide range of FofK found in diverse populations, such as those that populate Maryland schools.

Seiler (2001) applied FofK concepts to secondary science content during a lunch group at an urban high school. The students in the group were African-American males. During the lunch group, the students discussed topics in which they were interested outside of school. These topics included “playing basketball, baseball, video games, and drums, watching wrestling, cutting hair, and composing rap” (p. 1007). Seiler engaged the students in discussing the science involved in these activities. She states that “[in] their talk about drums and hair clippers the students recognized science in their everyday experiences, and I recognized them as experts” (p. 1008). Some students were able to show an understanding of scientific phenomena such as “the connection between the frequency of vibration and the pitch of sound” (p. 1008).

Seiler’s (2001) application of FofK worked well in the informal setting of a lunch group where discussing science topics during lunch was viewed as additional support. Seiler’s study involved only African-American males and student-selected science topics.

These applications of FofK were further modified in my own efforts to develop a Student-Centered Funds of Knowledge (SCFoK) Approach that takes the task of the fieldwork (gathering the FofK) from the teacher and gives it to the students. Students are given homework assignments that require them to ask family and community members’ questions that the student then relays back to the teacher (see examples below). Placing the task of doing research on the student makes the approach practical because it does not place expectations on teachers in terms of researching students' FofK and completing ethnographies on the many communities that their students represent.

A student-centered FofK approach benefits students in many ways. First, it allows students who come from a culture that is dissimilar from the "mainstream" the opportunity to understand how the content being learned at school applies to their lives. Second, it allows students who speak a home language that is different from what is being spoken at school the ability to discuss the subject in their first language before having to discuss it in English. Third, many students (especially those who have a home culture that is very different from the school culture) have relationships with their parents that break down as students find their parents' knowledge to be irrelevant to their social/academic experiences. Assigning students homework that involves them in learning from their parents and applying that knowledge in school helps to stabilize parent/child relationships.

In an intercultural communication course for teachers that I co-taught at the University of Maryland Baltimore County (UMBC) in 2009, a third grade teacher, Ms. Thompson, described her school district's curriculum that linked a unit on heat, light, and sound with the experience of camping. Camping, she told me, was intended to activate students' background knowledge and engage them in the unit. But, Ms. Thompson found that only about one third of her class liked camping, another third hated camping, and the remaining third had never been camping. As her final project for the course, she and two other teachers redeveloped the unit using a student-centered FofK approach. She and her colleagues decided that by changing the introductory question to: "What does or has your family used fire for?" was a way to incorporate a SCFoK Approach into the unit.

Students were asked to draw a picture of or write about three different ways their family had used fire. Interestingly, two of the students used campfires as a way that their family had used fire. One student drew a picture of using a campfire to cook marshmallows, while another student drew a picture of sleeping in a tent beside a campfire that provided heat to stay warm. Other students shared images of lanterns, fires for cooking, fireworks, and torches used to keep animals away. Students discussed their fire uses in small groups where they were able to be teachers as they told other students about their examples of fire. Then, students were asked to think about how their example produced heat, light, and sound. Later, students discussed forms of energy that create heat, light, and sound. By the end of the unit, students had learned the objectives of the traditional heat, light, and sound unit. In addition, they learned about a variety of ways that fire can be useful and about the diversity represented in the class and how families use fire differently. Perhaps most importantly, this type of lesson allowed students to begin to see themselves as having special knowledge that comes from being part of their family/culture and that their peers also have knowledge that is valuable to them. In this way, students learning from one another is empowering to all students.

It is clear to see how students can benefit from their FofK being used in formal education, but it is important to also recognize how this approach benefits other students in the class. By listening to the FofK of classmates, students from all backgrounds are able to gain understanding about the perspectives of others. Not only are they able to gain valuable knowledge, but they are given the opportunity to look at things in a way that is perhaps different from their own way of looking at things. Edward Said (1993) argues that historical texts containing “ideas of counterpoint, intertwining, and integration…with their interdependent histories [and] overlapping domains" are important to understanding our world (p. 259). If we believe this, we must also agree that the counterpoints and histories of students are important to be utilized in the class so that all students can understand the intertwining and integration of our global society.

It is not always an easy task for the teacher to connect the students' FofK with the content of the class. It requires that teachers know their content thoroughly so that they can adapt their lesson plans to connect with the information the students had learned at home or in the community. In addition, the teacher must know how to use the information so that it is incorporated into the curriculum in a way that builds understanding among students in the classroom. Because the teacher can never be sure of what a student might share, this can often be challenging. There is also the risk that a student might share information that is not congruent with what is being taught in the class. Some teachers develop a lesson plan and include examples in case their students do not share information that they are able to use for the lesson. As with all pedagogical practices, experience helps. When I began using this approach with high-school students, I found that it was sometimes difficult to use the knowledge students shared immediately, but, once several students had shared some of their FofK with me, I was able to draw from those funds for a variety of lessons.

Another challenge is that SCFofK is time consuming. This is because it takes time to explain the homework assignment so that students understand exactly what is being expected of them, it takes time for students to share their FofK with others, and it often creates an environment which is more interactive between students as they become interested in one another's FofK. Teachers who have used the approach consistently report that it takes about one additional class period to complete a unit using this approach as compared to teaching a more traditional unit. However, it is also important to realize that while creating a unit that is designed to utilize students' FofK takes more time, it also can be viewed as an investment that will benefit the teacher throughout the academic year. This is because as students share their FofK, the teacher will learn about her students' out of school lives and will be able to utilize that information in subsequent units. In one of my experiences teaching in a SCFofK program, students became so comfortable using this approach that they even applied the FofK shared weeks earlier by classmates to solve problems.

> During a class discussion, Eddie told us about what he learned from a conversation he had with his father. He then made a comparison between the water conditions in Liberia when his father was a teenager to the current water conditions in Baltimore's Inner Harbor. He reported that there weren't any fish in the water in Liberia because the water was so dirty. Then he said, "...the government and stuff they just went in there and everybody started thinking about how worse it could be if they don't clean it up. That why they try to keep it clean." It's interesting that "the government and stuff" quickly led to "everybody" starting to think about the environment. When asked if there was one particular person who started the change in how Liberians took care of the environment, he mentioned the governor. He said, "He started doing everything instead of thinking about himself. He started paying attention to nature and about the environment." Eddie's remark, "instead of thinking about himself" may mean that his perspective is that governmental leaders thinking about themselves is the norm.

> This governor, however, was different because he “started doing everything.” Eddie continued, “[The governor] say ‘pick up that bad stuff lying around in Liberia so it won’t be lying there for everyone to look at.’” He continued to tell us how clean the water in Liberia is now with “bunch of fishes.” From Eddie’s perspective, the governor was the agent of change that took a filthy environment and made it healthy. The environment went from “no fish” to “bunch of fishes.” In fact, the difference is so remarkable to Eddie that he restates “bunch of fishes” with more emphasis. Later in the presentation, Eddie stated that there is a fine in Liberia for cutting down trees and also for using too much gas. Here again, his theme is connecting caring for the environment with the government (Edmonds, 2008, p. 202).

Weeks later, the students had just finished studying water quality samples taken from their harbor. They were upset to learn that the quality of the water was so poor, especially in comparison to another body of water they tested in a nearby suburban area. The students began to talk about what they should do to improve the water quality. After a couple of ideas were raised and rejected by the group, one student recounted Eddie’s story and suggested that they contact the city mayor. Their hope was that action would take place similar to what happened when Eddie’s father was growing up in Liberia. All of the students worked together to write a letter that explained the problem and requested help.

This level of proficiency applying FoK should not be expected of students who are not using the approach in several consecutive units; however, the teacher should be able to recall the FoK students and remind the class of them. S/he would also be able to apply students' FoK to other units once one SCFoK unit has been completed.

Conclusion

In considering the ways in which FofK has been applied so far and the ways in which constructivism has been applied to science education, its clear that the concepts are similar, yet FoK never seems to get fully applied to science classrooms, especially at the secondary level. Perhaps it is because FofK works particularly well in the interdisciplinary context—a context that is difficult to apply to secondary education because our system divides students' days into content-specific periods that are taught by different teachers. However, a FoK Approach, that encourages "the teacher [to be] more aware of student world views as related to science" (Cobern, Gibson, & Underwood, 1995) may improve the quality of science education for students who typically do not do well in science and for those who do not like the subject (Cobern, et al., 1995).

Lemke (2001) states that science education needs to be redesigned to take into account sociocultural theory. There are examples of ways in which sociocultural theory is being applied in science education. Cognitively Based Science Instruction values students home cultures in the science classroom. As does FofK, Instructional Congruence links student's home culture with the learning that takes place in the science classroom. FofK respects students' home culture and views it as an asset to classroom learning. It allows students to be the experts about the knowledge they bring with them to school. Even the teachers can learn from them as they share about their experiences and the experiences of their families. It's this aspect of sociocultural theory that is missing from our secondary science classrooms today.

I'm not arguing for FofK to replace other constructivist approaches, but FofK in the secondary classroom is needed to achieve greater equity in culturally-, ethnically-, and linguistically-diverse classrooms.

Chapter 3: Methodology

Introduction

As discussed in Chapter 2, students' identities are integral to the degree to which students are engaged in classroom learning (Cummins, 2010).

I was interested in researching the ways in which teacher instruction takes into account the identities of students coming from diverse backgrounds. To learn about how students identify with science content, I conducted a collaborative ethnographic study with Dana, a female African-American high-school chemistry teacher, as she instructed chemistry to a group of 25 high-school students during the fall semester of 2011/2012. I returned for two weeks in January and February to observe her class while she taught a Funds of Knowledge (FofK) unit she had developed after completing a professional development unit that focused on using FofK in diverse classrooms. This collaboration included my learning about the strategies and techniques Dana already used to engage students by connecting classroom content (and assigned homework) with their identities as well as Dana learning through a professional development unit I designed and delivered. Using Geertz's "thick description" ethnographic methodology (1973), I have documented the many ways in which students from diverse backgrounds can be engaged in secondary chemistry.

Research Design

This section is organized into four parts. The first subsection states my two major research questions. The second subsection is a discussion that explains the purpose for each question. The third subsection describes the research methods used to learn about each question. It is meant to be brief; the Methodology section will describe each of these methods in further detail. The final subsection lays out the components and time frame for each phase of the project.

Research questions.

1. How does Dana build a learning community that incorporates students' FofK?
    - What strategies and techniques does she use?
    - How does she create an engaging classroom climate?
    - How does she build a community of learners?
    - How does she incorporate students' FofK/identities with the chemistry content being taught?
2. What are the implications of creating a learning community that incorporates students' FofK in the chemistry classroom?

Discussion of research questions.

The purpose of the first question (How does Dana build a learning community that incorporates students' FofK?) is to learn about the specific strategies and techniques, along with other classroom-climate related data, that Dana implemented in order to build a classroom of students into a learning community that utilized the knowledge students brought to the classroom from their out-of-school lives. These include ways that are related to students' FofK as well as other means she used to engage her students. As a chemistry teacher, Dana could have ways of helping students identify with the content that differed from my expectations. In addition, as a female African-American teacher, she may have used strategies or techniques that differed from other teachers who may not share her background. This question is based in Sociocultural Learning Theory, which views learning as being inherently connected with our identities. Dana's identity as a female and an African American (as well as other aspects of her identity) likely impacted the way she taught her students. I documented the strategies and techniques, and other classroom-climate related data, she used through field notes taken during classroom observations and formal and informal interviews.

The purpose of the second question (What are the implications of creating a learning community that incorporates students' FofK in the chemistry classroom?) is to discuss whether connecting students' FofK with high-school chemistry content is helpful in building a learning community. And, if it is helpful, what are the reasons that teachers would want to create a learning community that incorporates their students' FofK?

Together these questions will help me to better understand issues involving students' FofK in the secondary science classroom—particularly in the chemistry classroom.

Research methods.

To answer these questions, I used multiple methods. Below I discuss the method(s) I used to answer each question.

Question #1: How does Dana build a learning community that incorporates students' FofK?

To answer this question, I observed the class every day it was taught and took ethnographic field notes (Geertz, 1973). As I analyzed the data from these field notes, I expected to see a pattern that would show the techniques that Dana used. I also met regularly with Dana, both formally and informally, and used those meetings, in part, to ask questions that would clarify any questions I may have had when observing her classes.

Question #2: What are the implications of creating a learning community that incorporates students' FofK in the chemistry classroom?

To answer this question, I also took ethnographic field notes and met regularly with Dana. However to address the question, she and I worked together to create a unit plan using a student-centered Funds of Knowledge (SCFofK) approach (this approach is based on

FofK (Moll, 1992). I have modified Moll's original work in order to apply it in a culturally diverse classroom). After she completed the SCFofK Unit, I completed a final interview which was audio recorded.

In addition, I asked Dana open-ended interview questions aimed at encouraging her to share her thoughts about using a SCFofK Approach.

Phase components and time frame of research project.

The research plan proceeded in three phases. Before I began observations in Dana's class, I interviewed her primarily to learn about the sociocultural aspects of her personal experiences with science. This interview was aimed at learning about how and when she became interested in science, whether she had any particular role models in science or science education, and what her home culture was like when she was growing up. Essentially, I wanted to learn more about her FofK. I wanted to learn more about her teaching philosophy, the diversity of her classroom, her attitudes toward having a diverse classroom, what types of strategies/techniques she used with students, and what she hoped to gain from our collaborative work.

I observed Dana's class throughout the six-week Phase I period. During this time, I took ethnographic field notes documenting the methods and techniques she used to create an equitable classroom. Rather than wait until after the data collection was complete to begin to code data, I began to code it as soon as possible after I had collected it. Beginning to code data while the memory of a particular class was still fresh was helpful in writing a rich analysis.

During Phase II, I provided professional development (PD) for Dana after school that focused on cultural awareness, social constructivism, and how to use FofK in a secondary science classroom. Six readings were assigned during this period. During the first week of PD, she and I discussed an article titled: *Teaching science to English Language Learners: Building on Students' Strengths* (Rosebery & Warren, 2008, pp. 151-161). The purpose of this reading was to raise awareness of the ways in which schools are learning communities in which there can be a culture of inclusion or exclusion of students coming from diverse backgrounds. This reading was the basis for a discussion concerning school-wide and teacher/instructional practices that were in place at the school and in Dana's class. The second week of professional development focused on science instruction with nonmainstream students. The reading, *Science Education and Student Diversity: Synthesis and Research Agenda: Science Instruction* (Lee & Luykx, 2006, pp. 72-91) covered such topics as: culturally congruent science instruction, cognitively based science instruction, the sociopolitical process of science instruction, English language and literacy in science instruction, inquiry-based science instruction, and code-switching. Our discussion centered on finding out to what extent Dana was familiar with these topics and to provide additional information about any topics in which she was unfamiliar. During the third week, FofK concepts were introduced with: *Beyond Culture: The Hybridity of Funds of Knowledge* (Gonzalez, Moll, & Amanti, 2005). We gave particular attention to the "pedagogical validation of household knowledge with which students come to school" (p. 40). After our discussion on the FofK reading, we began to compile a list of the FofK that we already knew about the students. The fourth week we discussed *The Science Teacher: Challenges and Solutions for ELLs: Teaching Strategies for English Language Learners Success in Science* (Edmonds, 2009). This article discusses five primary challenges that ELLs face in secondary science education and offers strategies/techniques for each. SCFofK is also introduced briefly. This article helped

Dana and me to focus specifically on the needs of diverse students who are ELLs in the science classroom and the ways in which SCFofK and other strategies could support their learning. During the fifth week, we discussed *Con Respeto: Bridging the Distance Between Culturally Diverse Families and Schools: An Ethnographic Portrait* (Valdez, 1996). This book is an ethnographic account of the school/parent relationships of Mexican immigrant students. It chronicles many failures of a U.S. school to build positive relationships with Mexican immigrant families and it illustrates the negative affects this has on students. Finally, during week six, we discussed *Boxes, Bags, and Videotape: Enhancing Home-School Communication through Knowledge Exchange Activities* (Hughes & Greenhough, 2006, pp. 471-487) about specific activities teachers can use to learn about students and their families' FofK. This aided us in beginning to consider the type(s) of activity Dana would like to use with her students. The final reading discussion was completed on the 12th week of the study, which was the sixth week of PD.

On the seventh week of PD, Dana and I focused on identifying chemistry units which she felt were suitable for using a SCFofK Approach. We also began to plan the SCFofK unit that was scheduled to begin during the second week of February, 2012. We continued to work on the SCFofK Unit during PD for several weeks (see Appendix B for Collaboration Schedule and Professional Development). This phase ended with Dana instructing a chemistry unit that had been developed to use a FofK approach. Phase II, as explained above, took place over 10 weeks. I continued to observe instruction, transcribe notes, and conduct first level of coding during this period.

The final phase lasted two weeks and took place after all PD and the FofK Unit had been completed. The purpose of this phase was to see how Dana was able to implement a SCFofK approach independently. During this two-week period, I continued to observe instruction in the same manner as was done during Phases 1 and 2. Phase 3 ended with a closing interview.

The table below summarizes the components and the time frame for this research project.

Phase	Methods	Other Data	When	Date(s)
Phase 1: Pre-PD Phase	Formal Interview 1		Before the beginning of the phase	Before the week of September 12, 2011
	Field Notes		Throughout the phase	September 12-October 17, 2011
	Informal Interviews			September 12-October 17, 2011
Phase 2: PD Phase	Professional Development		Throughout the Phase	October 24-November 28, 2011
	Field Notes		Throughout the phase	October 24, 2011-January 13, 2012
	Informal Interviews			October 24, 2011-January 13, 2012
		Collect Baseline Unit Plan	Before development of SCFofK Unit Plan	Week of December 12, 2011
	Compilation of known student FofK		At the beginning of the PD that focuses on FofK	Week of December 12
		Collect SCFofK Unit Plan	Before the unit is enacted	Week of January 3, 2011

	Final Interview and Compilation of additional known student FofK		At the end of the FofK Unit	Week of January 13
Phase 3: Post-PD Phase		Collect Unit Plan Revisions	During informal interview	Week of February 13-23, 2012
	Field Notes		Throughout the phase	Week of February 13-23, 2012
	Informal Interviews		Throughout the phase	Week of February 13-23, 2012

Figure 3: Phase Components and Time Frame

Population

As is true across the United States, the population in Maryland is becoming increasingly diverse. At the time of this research, the 2010 Census revealed that the historically non-Hispanic White majority comprised only 54.7 percent of the Maryland population (in 2014, it was 52.6 percent). African Americans accounted for 29 percent of the population (in 2014, it was 30.3 percent), while Hispanics made up 8.2 percent (in 2014, they made up 9.3 percent) and Asians made up 5.5 percent (in 2014, they made up 6.4 percent) of the population. The remaining 2.2 percent (3.3 percent in 2014) was made up of non-Hispanic people of color and people of multiple races (Maryland Department of Planning, 2011). While these statistics indicate a non-Hispanic White majority in the state, several school districts now have a population that consists mostly of people of color. Baltimore City and Prince George's County have long had a majority population consisting of people of color (Department of Legislative Service, 2008). Baltimore County also consists of a population where more than half of its population is people of color. Montgomery County (50.7 percent) and Charles County (51.6 percent) have become people-of-color majority counties (Maryland Department of Planning, 2011) and Howard County was expected to follow this same trend with the majority of its students as people of color at the start of the 2011/2012 school year. Between 2000 and 2010 Montgomery County's population of people of color grew by 10.2 percent due to substantial increases in Hispanics, Asians, and African Americans. Montgomery County also experienced a decrease in non-Hispanic Whites. In 2012, it was projected that Maryland would become a people-of-color majority within ten years (Goldstein, 2012)

A growing Hispanic population is evident throughout the state. In fact, in Prince George's, Montgomery, Anne Arundel, and Baltimore Counties and in Baltimore City, Hispanics were the largest source of population growth. Howard County also experienced population growth, but the largest component of their increase was due to growth in the Asian population. In 2010, Asians comprised 14.3 percent of the population in Howard County (Maryland Department of Planning, 2011).

While the 2010 Census indicates that the largest source of growth in Maryland is due to an increasing Hispanic population, it is important to recognize that this population in itself is very diverse. According to the Pew Research Center Country of Origin Profiles (2008), Mexicans comprise 65 percent of Maryland's Hispanic population followed by Puerto Ricans (8.8 percent), Cubans (3.5 percent), Salvadorians (3.3 percent), Dominicans (2.8 percent), Guatemalans (2.1 percent), Columbians (1.8 percent), Hondurans (1.3 percent), Ecuadoreans (1.3 percent), and Peruvians (1.1 percent). Even though the majority of the Hispanic population is listed as having Mexico as its country of origin, the country of predominant origin for the foreign born is the more recent immigrants from El Salvador (Goldstein, 2006). Goldstein (2006), in a presentation by the Maryland Department of Planning, showed that according to U.S. Census data, foreign-born Hispanics in Maryland were more than twice as likely to have been born in El Salvador as in Mexico. This indicates that while the largest Hispanic population in Maryland is currently of Mexican heritage, the relatively small population of Hispanics of Salvadorian heritage is growing rapidly.

In addition to the diversity of countries, there is also substantial diversity within each Hispanic country. Many Latin-American countries have more cultural diversity than one might expect. Assumptions about immigrants' culture can't be made based solely upon their country of origin. In fact, for many Latin-American immigrants Spanish is not their native language.

The diversity statistics I've discussed so far point to an increasingly diverse Maryland population; however, these figures are even more compelling when we take into consideration the portion of the population that attends Maryland Public Schools. During the last ten years, the White population under the age of 18 has dropped below 50 percent (Latshaw, 2011). Although this discussion is about Maryland, similar cultural diversity exists more and more across the United States.

Research Site

Through my university position as a supervisor of teacher candidates who conduct their student teaching at various secondary schools in Maryland, I had the opportunity to observe many different teaching environments. I purposefully selected Mid-Atlantic High School because of the school's appreciation for its diverse population. Some examples of this positive attitude were written in online reviews. One student wrote, "[Being] a diverse school it is easier in the [World] to get along with people. [In] school [I] learn about [different] people and their [cultures] so when [I] see people in the [World] it is easy to understand their views and get along with them." A parent posted,

> Our school celebrates diversity. We have students of every race and it is a joy to see them all dismiss the differences and simply be friends. I really hope that our school is a window into the future where people of all types cooperate, respect and admire each other. The administration here also seems to really care that the students do well, stay in school and become the person they are meant to be.

There were several positive statements about the school's diversity such as these. It's important to recognize, however, that not everyone had such a positive attitude about the school's diversity. One parent posted, "**… families beware, the majority of kids in this school** come from Frontier City, this [is an] area [in which] all military are legally FORBIDDEN to live in, yet our children are forced to go to school [with] them, trained combat [soldiers] are forbidden to live in this town but our military children are forced to share a school, scary thought! Oh, *Daily Star* article, quotes Mid-Atlantic High blaming the military kids too, what a joke!" Another parent responded to this statement by posting, "**Re: military families remark.... NOT true that most kids are** from [Frontier City]! Kids come from all over…which is a NICE neighborhood! And the IB program attracts students from all over! And who do you think you are? You think military kids are better than Frontier City kids?? OH! PLEEASSSEEE!! My daughter is in her second year, and loves it! She is an athlete and an IB student... coaches and teachers are great! There [have] not been any fights or other discipline problems @ Mid-Atlantic High! It is a tightly run ship!"

According to the district's high school enrollment data for 2010-2011, the student population at Mid-Atlantic High School was 2285. There were: 1305 (57.1 percent) students identified as African American, 521 (22.8 percent) students identified as White, 266 (11.6 percent) students identified as Hispanic, 131 (5.7 percent) students identified as Asian, 50 (2.2 percent) students identified as being of two or more races/ethnicities, eight (.4 percent) students identified as Indian, and four (.2 percent) students identified as Native Hawaiian. A little more than half of the student population is female (1146 females and 1139 males). Students qualifying for free- or reduced-meals (FARMS) due to low family income represent 29.6 percent of the student population (NCES, 2005).

Mid-Atlantic is a school that is doing well, in terms of meeting Adequate Yearly Progress (AYP) in all areas in 2010. According to the 2010 Maryland Report Card, they had met AYP in all measured areas since 2005. It is important to note how much focus was placed on equity and community engagement in the School Improvement Plan for 2010-11. The plan listed five goals, which were: 1) academic achievement, 2) safe and supportive learning environment, 3) workforce quality, 4) community engagement and 5) equity. Even though it appeared that only two out of five goals were oriented toward equity and community engagement, the first goal (academic achievement) also had a focus on equity. The academic achievement section of the plan showed 13 tables each illustrating the percentage of students scoring proficient in a particular academic area. Each percentage was then broken down by groups (African American, American Indian/Alaskan, Asian/Pacific Islander, Hispanic, White, ELL, FARMS, and SPED or students who received special education services). The goal one indicator stated, "By the end of the 2011-12 school year, 95% of all [Mid-Atlantic] High School students will score proficient or higher in the Biology, Algebra, English, and Government [High School Assessment]." Achievement of groups based on race, gender, and socioeconomic status will not vary" (2010 School Improvement Plan). One indicator that the school (actually the entire school district) was serious about equity came from an email I received from Dana. She wrote: "[The] county's new platform [for closing achievement gaps] claims to provide opportunities for professional growth in the area of teaching and learning, especially for African American and ELL subgroups."

Not only did Mid-Atlantic High School value equity, community involvement, and diversity, it also stood out as an exceptional high school to such an extraordinary degree that *Newsweek* listed it as one of America's Top High Schools (Mid-Atlantic was one of 1623 schools, or 6% of the nation's high schools, to make the list). *Newsweek* stated that their rankings were based on "how hard school staffs work to challenge students with advanced-placement college-level courses and tests." The write-up stated,

> Our mission at [Mid-Atlantic High School] is to be recognized throughout [the state] for providing rigorous, relevant, and engaging learning to a diverse community of learners within a respectful, and culturally sensitive environment, in order to cultivate effective citizens, workers and lifelong learners who will positively impact society for generations to come.

Given that terms such as "diverse community" and "culturally sensitive" were used even in very short descriptions of the school, it's clear that these characteristics of the school were important to the school community.

Dana reports that the classes are even more diverse than that of the total student population of the school. That may be because the classes are designed for students who would not normally track into a chemistry course. Dana expressed very positive feelings toward her co-taught class. At Mid-Atlantic High School, the term "co-taught" is used to refer to a class that is composed of lower-performing students, ELLs, and other students who have special needs. Many of the students who have disabilities have an Individual Education Plan (IEP) that specifies the accommodations they are to receive. Bill, the co-teacher in these classes, is a special educator; a high percentage of the students in the co-taught class receive special education services or speak English as a second language.

Dana was the chair of the science department and appeared to have excellent rapport with her students. She had not previously received formal professional development centered on ELLs; however, she had stated on several occasions that she was interested in developing her skills with ELLs and students who traditionally don't do well in science.

One drawback of Mid-Atlantic High School was the mobility of many of the students. At this school, it was much more common for students to move to the area during the school year. It was also more common for students to move away before the academic year was completed. Otherwise, given my research interests, Mid-Atlantic High School was an excellent environment for research involving equity in secondary science education and Dana was an excellent teacher to study.

Data Collection

As stated earlier, the purpose of this qualitative study is to describe the ways in which a high-school chemistry teacher moves a diverse group of marginalized students from the margins of science learning toward the epicenter of the science-understanding community. I used ethnograpc methods of data collection for this research. Ethnography is "a powerful multistranded method first developed by cultural anthropologists and now adopted by researchers in many disciplines, from political scientists and economists to scholars of education and media studies" (Gottlieb, 2006, p. 47). To implement a multistranded method using various techniques, I collected data to examine the strategies and techniques Dana used with her students in her chemistry class. Another strand of my research was providing Dana with professional development focused on using a Student-Centered Funds of Knowledge (SCFofK) approach and collecting data on the delivery of the SCFofK activities she used in class.

Four data sources—classroom observations, participant observation, informal interviews, and formal interviews—were collected and analyzed in order to explore the specific strategies and techniques Dana used to teach her students, as well as to discover the ways in which students' identities and experiences could be connected to high-school chemistry content.

Classroom observations.

Ethnographic field notes were taken in my researcher's journal during classroom observations from the week of September 12th through the week of January 12th, 2011, (Phases I & II) and then again from the week of February 13th, 2011, through the week of February 23rd, 2012. The class met on a block schedule (90 minutes on alternating days) and the observations took place during every session. When writing field notes, I did so using Geertz's (1973) concept of "thick description." Thus, I immersed myself in writing about seemingly mundane activities as well as inscribing what stood out as being particularly interesting. In this way, I was able to document data that would eventually enable me to describe richly the strategies and techniques Dana used to help students identify with the science content (question #1). "Fieldnotes grow through gradual accretion, adding one day's writing to the next's" (Emerson, 1995, p. 10). I continuously analyzed data and, therefore, became more aware of the significance of certain actions. (See section on Methods of Qualitative Analysis for a discussion on how I analyzed my field notes).

Participant observation.

I used participant observation as a technique to gather data through direct participation with Dana as I provided professional development on using Funds of Knowledge (FofK) and as I collaborated with her to develop FofK activities for her to use in the classroom. Participant observation enabled me to work in a natural setting with Dana while collecting data, through field notes, on her ways of incorporating SCFofK activities into her previously existing chemistry lesson plans. According to Schensul, Schensul, and LeCompte (1999), participant observation is "the process of learning through exposure to or involvement in the day-to-day or routine activities of participants in the researcher setting" (p. 91). Thus, my interactions with Dana as a participant observer enabled me to learn about how she gleaned knowledge from the articles we read and discussed and then incorporate that knowledge into the lesson plans she would use with her students.

The participant observations began at the start of Phase 2 of my data collection. This was the 10-week period in which I provided Dana with professional development on FofK. For the first six weeks of Phase 2, we discussed a reading that I had given her the week before. Rather than asking comprehension questions, I allowed Dana to reflect on the readings and to talk about how they might be applied to her classroom. I allowed her to say what was important to her by not asking probing questions that might impact what she shared. Only after she was finished speaking, did I ask follow-up questions if I had any. I took notes during our interactions and developed them in detail immediately afterward. The purpose of these field notes was to be able to write a "thick description" of the learning environment as it pertains to my research.

Informal interviews.

Informal interviews are conversations that I had with Dana that were not part of a formal interview. These moments often arose spontaneously before or after class or if I saw Dana when I was at the school for unrelated purposes (such as to observe a teacher candidate that I supervised). Informal interviews also took place when we attended the annual Brown Lecture, which features topics focused on equality and equity in education. After each of these interviews, I wrote reflective summaries of our conversations. Although I have given separate categories for participant observation and informal interviews, it is worth noting that the two go hand-in-hand (Fontana & Frey, 2005); categorizing them separately acknowledges the different roles in which I perceived myself. As a participant observer, I was situated in my role as a teacher educator. When conducting informal interviews, I was an ethnographic researcher.

Another distinction to be made is the difference between the types of interviews.

> Malinowski's (1967/1989) "day in the field" shows how very important unstructured interviewing is in the conduct of fieldwork and clearly illustrates the difference between structured interviewing and unstructured interviewing. Malinowski has some general topics he wanted to know about, but he did not use close-ended questions or a formal approach to interviewing (p. 706).

Formal and informal interviews differ in that the former aims at capturing precise data, whereas the latter attempts to gather data without "imposing any a priori categorization that may limit the field of inquiry" (p. 706).

Formal interviews.

Formal interviews took place when Dana and I planned to meet. The purpose of our meetings was to discuss specific questions I had prior to beginning to observe Dana's class, as well as a final interview held after Dana had taught the FofK unit she had developed. These interviews followed the pre-approved IRB protocol.

The purpose of the Pre-Observation Interview was to learn about Dana's: 1) personal FofK that related to science, 2) perceptions of the ethnic and racial diversity in her classroom, 3) strategies and techniques she used in order to help students with diverse backgrounds, and 4) the role of the special educator who "co-taught" the class. During the interview, I also questioned Dana about the knowledge or skills she hoped to gain from the research project. The purpose in asking this question was to make sure that the professional development being offered during the second phase of the project addressed areas of interest to Dana so that change could be made if necessary. This interview was completed prior to the first observation and lasted about one hour (see Appendix C for interview protocol).

The final interview, or Post-Professional Development Interview, was carried out in a manner that was intended to encourage Dana to share all of her thoughts (both positive and negative) regarding her experiences. For this reason, the questions were open-ended, the interview setting was designed to be comfortable, and the interview began with less formal talk to help ensure that Dana was relaxed. The first question asked Dana to give feedback regarding the write-up of my classroom observations. This member check was important in making sure that my interpretation of classroom interactions was accurate. "[Anthropological] writings are themselves interpretations, and second and third order ones to boot. (By definition, only a "native" makes first order ones: it's *his* culture.") (Geertz, 1973). In this case, Dana's science class was her "culture." I was there as a non-participant observer. What I observed was documented as I perceived it, but I asked Dana for clarification of any events in which I had questions.

As part of the final interview, Dana and I discussed both a unit plan she had written and had taught the previous year as well as the unit plan that we collaboratively developed.

Summary of Data Collection

The data collection lasted for 18 weeks, and included interactions with and observations of a high-school chemistry teacher and her chemistry class, which was developed for students who normally would not take high-school chemistry. A formal interview was conducted at the beginning and the end of the research period. Classroom observations occurred during Phase 1 and Phase 2, and then again when Dana delivered the FofK unit that she had developed independently. Informal interviews took place throughout the data collection period. Participant observations occurred for 10 weeks during Phase 2 while I was providing FofK professional development for Dana and as we collaborated on FofK activities she could use with her students. Data for all of these methods was collected in my researcher's journal.

Data Analysis

This research used two data analysis methodologies. The first, Grounded Theory led to identification of domains which were later used to code for thematic analysis.

Grounded Theory.

Grounded Theory (Strauss & Corbin, 1994) is an approach that attempts to generate theory from observation by repetitiously categorizing and analyzing data (Calloway & Knapp, 1996) "with each informing the other throughout the research process" (Charmaz, 2005, p. 508). Recently scholars, including Charmaz, have sought to move Strauss' version of Grounded Theory away from positivist aspects of its procedures toward a method of analysis that is constructivist (Charmaz, 2005). Constructivist Grounded Theory is more reflexive concerning ways of knowing and ways of representing studied life. "That means giving close attention to empirical realities and our collective renderings of them—and locating oneself in these realities" (Charmaz, 2005, p. 509). A constructivist view recognizes that what researchers see and hear is influenced by their experiences and relationships with participants. Because I share this perspective, I was reflexive as I wrote my field notes. I thought about possible alternative interpretations. One of my goals each week, during the informal interviews, was to ask questions that could help me better understand the meanings behind observed classroom events. I expected that Dana would be able to offer other perspectives of my account that would further enrich my work. I had decided that if she and I had a disagreement about an aspect of the analysis and were unable to come to an agreement, I would write both sides and explain the disagreement in the analysis. Therefore, my researcher's journal was written so that it could be read at four different levels: 1) the field notes written as an account of the actions observed coming from my perspective but without my judgment; 2) my reflexive thoughts that revealed my thought processes as I struggled to make meaning of the field notes; 3) my analysis of the field notes; 4) my reanalysis that included Dana's response to my initial analysis if I found that she and I had differing perspectives (see Chapter 1: Ethics).

Because "Grounded Theory entails developing increasingly abstract ideas about research participants' meanings, actions, and worlds and seeking specific data to fill out, refine, and check the emerging conceptual categories" (Charmaz, 2005, p. 508), I analyzed my data from one observation before doing the next. This helped me to focus my observations based on my forming hypotheses. Having an ongoing analysis throughout the study also allowed me to have an understanding of the observations so that I could ask Dana follow-up questions that could help clarify the significance of certain classroom events.

Thematic analysis.

After completing an analysis of the data using a grounded theory approach, I applied thematic analysis to code every word of my data. Phrases and terms such as politeness, evidence of positive student-to-student relationships, student helping student, teacher identity, teacher references student's FofK, modeling, gestures, and evidence of teacher caring were identified and used as codes. These codes were then grouped into larger themes and used to discuss the first research question, which was: How does Dana build a learning community that incorporates students' FofK? The larger themes used to answer this question were: strategies and techniques, individual interactions between Dana (or Bill) and students, evidence of student engagement, positive relationships, and teacher shares personal science-related stories with students. These themes were again grouped into larger domains to make up main topics such as: Engaging Classroom Climate, Positive Emotional Climate, Encouraging FofK/Identity, and Encouraging Community.

Validity & Reliability

In ethnographic research, validity is the degree to which the findings of the study accurately express the real-world facts that they aim to describe (Wilcox, 2008). In order to establish validity, I carefully documented what I saw and heard in Dana's classroom. I used data from informal interviews, participant observations, and formal interviews to triangulate my data. Triangulation was used as a means to demonstrate reliability. It combines "multiple methodological practices, empirical materials, perspectives, and observers in a single study…as a strategy that adds rigor, breadth, complexity, richness, and depth to an inquiry (Denzin & Lincoln, 2005). Although I established reliability of the study by implementing three methods for verification, this research will truly be deemed valid when it solves the problem of the marginalization of diverse students in secondary science classrooms.

> [Cogenerated] contextual knowledge is deemed valid if it generates warrants for action. The core validity claim centers on the workability of the actual social change activity engaged in, and the test is whether or not the actual solution to a problem arrived at solves the problem (Greenwood & Levin, 2005).

Limitations

This study analyzed the ways in which Dana's students moved from a position of being institutionally marginalized to 1) becoming engaged in learning science, 2) becoming part of a learning community within their classroom, and 3) moving toward an epicenter in which citizens are members of a science-understanding community. Dana's class was made up of students who had been marginalized due to being identified as a non-native speaker, a student with an IEP or 503, or having previously failed chemistry. This study did not take into account students who may be marginalized in other ways such as students who self identify as LGBT or students who may have needed the types of support Dana's class offered but weren't placed there due to positive stereotypes. Third-wave Asian students often fall into this group. These are students who have been positively stereotyped (model minority) as being high achievers due to Asian immigrants, such as Koreans, who tend to be very successful in the American academic setting (Cheryan & Bodenhausen, 2000). To many Americans, Asian Americans appearance is very similar; however, in reality, there is a wide range of academic success among and between third wave Asian immigrants.

Dana's class was very diverse; in fact, it was more ethnically diverse than the general Maryland population. The fact that the class was very diverse and that the school had a culture of valuing diversity (see Research Site, above), made it an ideal setting for this research but also posed possible limitations. It is important to acknowledge that the results of this study may not be replicable in a different school setting. However, this does not diminish valuable guidance this study provides regarding moving students from the margins of science learning toward the epicenter of a science-understanding community by building a FofK learning community in which participants' identities are recognized and valued as part of science learning.

Conclusion

Throughout this research project, I investigated the ways in which a female African-American teacher connected chemistry content with the identities of students coming from diverse backgrounds using her own strategies and techniques and a SCFofK approach. Analyzing field notes from classroom observations, participant observations, and formal and informal interviews enabled a detailed inquiry regarding the connection between student identity and secondary-chemistry content in a diverse classroom.

Chapter 4

From the Margins: Laying a Foundation for Science Learning

Dana's class was made up of students who had an Individualized Education Program (IEP) or a 504 Plan, students who were English Language Learners (ELLs) or who had recently exited the English for Speakers of Other Languages (ESOL) Program, or students who had not performed well in previous science courses. IEPs are developed for students who have been determined to require specialized instruction in order to learn the academic content of the course, whereas 504 Plans are written for students who, although they don't need a completely individualized plan, need specific accommodations in order to succeed in the course. ELLs and students who have recently exited an ESOL program typically require additional language support and may struggle with relating to American ways of perceiving the sciences (Edmonds, 2009; Lee, 2005). Not only did Dana have students who were institutionally marginalized due to a learning disability and/or their English-language proficiency, there were also students who had previously failed chemistry. These students were likely to have negative feelings about chemistry due to past experience with failing the course. For these reasons, Dana's class was made up of students who were not expected to perform well in a typical high-school chemistry class. Prior to the pilot of this course (Dana had taught this course as a pilot during the previous year. Her school principal had developed the course as part of his dissertation research), most students who had an IEP, a 504 Plan, were limited English-language proficiency, or who had a previous unsuccessful attempt to take chemistry, would not have completed high-school chemistry, and; therefore, would not have been considered college-ready upon graduation from high school.

In this way, these students had been marginalized. Marginality occurs when participation is restricted by non-participation (Wenger, 1998).

The school principal had explained that the students in Dana's class were not the ones who would typically take chemistry in high school. In other words, due to institutional arrangements, these students would normally be restricted from participation in a high-school chemistry course. Or, due to previous failure of high-school chemistry, some students may have self-identified as non-participants in order to avoid failing for a second time. For students who had failed, Dana's class offered another chance to move from the margins of science learning toward becoming part of a science-understanding community. Students who "would not typically take chemistry in high school" were also being given an opportunity to move beyond their institutionally-induced marginalization toward becoming a member of the science-understanding community.

Students in Dana's special chemistry course, would either learn science that would enable them to be included as members of a science-understanding community or they would fail and remain at the margins. Perhaps they would leave with a better understanding of science, but they would continue to be barred from the "college-ready community."

Note: In the discussion that follows, I want to distinguish between a science-understanding community and the science learning-community. A science understanding community refers to people who are competent to discuss science-related topics as they arise in the community. For example, Dana tells a story about how she would accompany her grandmother to doctors' appointments so that she could "translate" for her. Her grandmother was a native speaker of English, but she didn't have enough science understanding to feel competent talking with her own doctor. She was not a member of the science-understanding community. On the other hand, Dana, who was asked to communicate with the doctor on her grandmother's behalf, was part of that community. The science learning-community is the community of learners that developed within Dana's classroom.

Moving from the Margins Toward a Science-Understanding Community

The students in Dana's chemistry class were marginalized, at least when it came to science. However, once students were placed in Dana's chemistry class, there were many ways in which she began to move them from the edge of science understanding toward the epicenter of the science-understanding community.

Figure 4 below shows how students moved from the margins of science learning toward a science-understanding community. This transition was able to occur because Dana provided an engaging academic classroom and a positive emotional climate that enabled her to then build a learning community. Once the learning community was established, students were able to work together with their teacher to become members of the science understanding community.

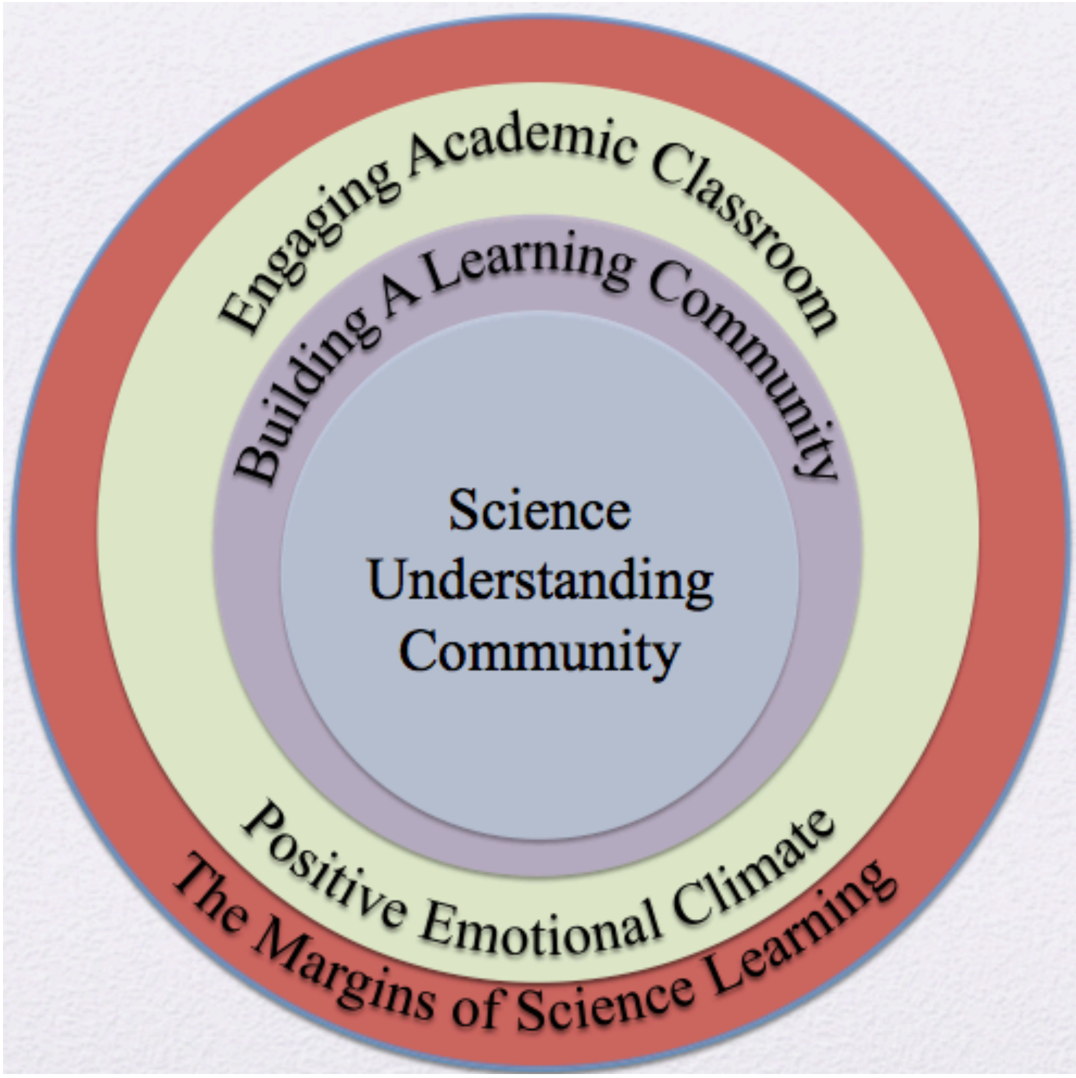

Figure 4

To show how Dana moved students from the margins of scientific understanding toward the epicenter of the science-understanding community, I will discuss the characteristics of Dana's classroom that were needed to establish a science-learning community that incorporates students' FofK. These characteristics fell under two main categories: 1) an engaging academic classroom and, 2) a positive emotional climate. Once the environment was established, Dana's class was able to move further toward the ultimate goal of establishing science-understanding citizens who would be capable of participating in scientific discourse in the community. (For purposes of this study, scientific discourse is communication regarding science as it impacts the life and interests of an individual and/or a member(s) of his or her community.) After discussing these characteristics and how they created an environment conducive for establishing a science learning-community that incorporates students' FofK, I will provide evidence that a science learning-community that incorporated students' FofK was present in Dana's chemistry class. Finally, I will discuss how establishing this learning community served to develop students who would be part of the science understanding community rather than students who merely passed high-school chemistry as a requirement to check off on the college-bound list.

Engaging Academic Classroom

An engaging academic classroom was one of two environments that Dana created in order to move her students from the margins of science toward a science understanding community. Having an engaging academic climate was vital to her being able to build a learning community. There are many ways in which Dana created an engaging academic classroom. By engaging, I mean that an environment was present in which students actively participated through 1) asking and answering questions, 2) participated in lab experiments, 3) working collaboratively, and 4) positively interacting with one another. In order to create the environment, Dana employed several strategies and techniques that included: modeling, general studying and learning skills, analogies, gestures, and general verbal encouragement. She also interacted individually with students, Bill also did this.

There is evidence of student engagement in Dana's chemistry class; this will be discussed at the end of this section.

Strategies and techniques.

Below are strategies and techniques Dana used that either helped to create an engaging academic classroom or acted to remove a barrier to engagement. This discussion is not intended to cover exhaustively all of the strategies and techniques used in the classroom. Rather, the strategies and techniques discussed below, along with the sub-section that follows titled "Individual Interactions with Dana (or Bill,)" laid a foundation for student engagement. The section that follows "Engaging Academic Classroom" is "Positive Emotional Climate." Positive emotional climate both worked with and built upon the engaging academic classroom to establish an environment in which a FofK community of learners could be built.

Modeling.

As part of her normal teaching routine, Dana used modeling so that students would understand exactly what they were expected to do. When students were asked to solve a new type of problem or to do a task they had not performed before, Dana would perform the task first while they observed. Modeling is a powerful visual demonstration that shows students how to perform a task. Modeling removed a barrier to participation and aided student engagement. In addition to consistently modeling the first few problems of an assignment, Dana used modeling to show students how to perform apparently simple tasks, but ones that might be confusing to students who were not fluent in standardized English. For example, she modeled for students how to orient their paper to a landscape position. She also modeled note-keeping skills such as writing definitions and other information in the students' notebooks and how to organize them so that they could easily navigate their notebook to find specific information. In addition to modeling how to solve a certain type of problem, she modeled how to check to make sure solutions were calculated correctly and how to find an error made when solving a problem. Modeling was also used to demonstrate how to perform lab tasks properly. Before students were asked to do a FofK project, Dana did her own and presented it to the class in the same way that they would do their own projects. For example, modeling was used to show students how to distinguish between physical and chemical properties.

Dana also used student work that was done accurately to model for other students how they could solve a problem. Before she used student work as a model, Dana would ask the students and give them the opportunity to model it themselves using the document camera to show their work.

General Studying and Learning Skills.

Another strategy Dana incorporated that served to create an engaging academic classroom was teaching students general studying and learning skills. For example, before teaching her students a lesson on molar mass (they had just transitioned back to their seats after doing a lab activity), she had the students take a minute to settle themselves. To do this she said, "Jeremiah, in just a couple seconds we are starting our minute of quiet and calm. That means you are going to think about what you need to do to refocus because we have a lot that we have to accomplish." Her saying this prompted the entire class that they were going to refocus before talking about molar mass, which gave them a chance to prepare themselves mentally for learning. Jeremiah, though, was being redirected from behavior that did not appear to be focused on learning. Yet Dana interacted in a manner that was not reprimanding; rather she was encouraging Jeremiah and his peers to refocus so that he would understand molar mass concepts. Furthermore, her use of the word "we" served to include him as part of the learning community. Had she, instead, used the word "you," Jeremiah likely would have felt that he was being singled out as if he were a disruption to the class. Her statement was effective in that it helped to create an inclusive environment in which everyone—even those who were not currently focused on the content—were encouraged to engage in learning. This is just one example of the way in which Dana would teach studying and learning skills.

Analogies.

Dana used analogies to help students make sense of an abstract concept. In one example, she began the analogy by asking the class, "How many people have experience popping popcorn?" At first just a few hands went up but soon more students raised their hands. Dana explained to her students that electrons have higher energy levels when they are excited, just as popcorn gets excited when energy (heat) is applied. Next, she used the document camera to display a photo of people jumping. She explained that they can't stay up; they have to return to the ground. "Energy is lost in the form of light," she said, "when electrons drop back to the ground state."

According to Dana, understanding the Periodic Table is another difficulty that her students often encounter. After learning about using a FofK Approach, Dana decided to try to incorporate her students' personal lives by using their names as an analogy to explain the Periodic Table (see section on Evidence of FofK Exchange for further discussion).

Dana used the students' recipes to make analogies to help explain how to identify reactants and products which would later be used to classify the five types of chemical reactions. By using these analogies, students were better able to conceive what products were and what was meant by "reactants." For example, she drew on how the ingredients of spinach, cheese, butter, and a scant amount of cream come together to form a product (Palak Paneer) just as elements react together and form a product. She also used the food analogy to discuss substitutions (replacements).

In the previous examples, the analogy was planned in advance; however, Dana also used analogy spontaneously to help when students appeared to be confused. For example, in a lesson in which students were supposed to be able to determine the shapes of covalently bonded molecules by applying the VSPER theory and building molecular models, students expressed confusion. First, Dana built a wooden model of H_2O and placed it on the document camera before asking, "Why would the opposite end be the negative?" When many students appeared to be confused, Dana used a visual analogy where she and Rodrigo were miming a game of tug-of-war. She asked the class who was going to win the tug-of-war. Then the class discussed why Rodrigo was going to win. After a student stated that Rodrigo would win because he was bigger, Dana repeated the answer loudly to ensure that everyone heard.

Dana also applied an analogy from chemistry to give behavioral instructions. One example was when the class was playing a game in which groups of students raced to come to a consensus on the correct answer. Some students were out of their seats moving around when Dana said, "Okay let's listen guys. You can't be floating around like a free agent." This comment got the attention of several students; some looked at her while others repeated "free agent."

Bill also used analogy as a behavior management technique. An example of this is illustrated in this exchange: Dana had just instructed students to pair up and find another student who had written something on his or her paper that was related to what they had written on their own. Many students remained in their seats. Bill said, "Okay, so we don't want to be like a solid right now; you want to be more like a gas."

These examples demonstrate how analogies were used to help students understand difficult abstract chemistry concepts as well as to help students apply chemistry concepts to everyday activities. Dana and Bill's use of analogies also served as a model of how students could draw on their knowledge from things they understood well in order to help them understand more complex concepts.

Gestures.

Gestures are non-verbal cues that assist comprehension (Enright, 1992). Gestures can help all students' comprehension, but it is imperative that ELLs receive instruction using non-verbal cues so that they can understand what is being taught (Crandall, 2009). Dana used gestures when she taught a concept to her class and to remind them of a concept they had been previously taught, as well as to express to a student her relationship to the class as a whole.

The following example demonstrates one way in which Dana used gesturing to help students understand a concept:

> Dana had stated that electrons absorb energy. She then asked, "Where do they go?" Several students called out, "higher." She responded, "But they don't stay there. Where do they go?" Some students called out, "Back down." Then, Dana used her whole upper body to demonstrate higher by reaching into the air. Then, her facial expression made her appear to be tired as she talked about the energy going back down. She bent down and reached her arm toward the ground as she exclaimed, "Very good, Vincent!"

Dana's gestures created a context to aid her students in their understanding. "By creating a context students are able to link what they are learning to previous knowledge or experiences while at the same time make new connections cognitively which can later stimulate memory" (Bilash, 2009). Depending on the students' backgrounds and experiences, the gesture may have prompted them to recall the saying, "what goes up must come down" or they may have thought about how they have more energy at the beginning of the day but are tired after being up all day. They may have connected the lesson with an experience or knowledge that is unique to their culture. No matter what the connection, gestures help the students to make meaning out of complex and abstract concepts.

During another lesson, Dana wrote on the Smart Board, "Ionic bonds are the attraction between cations and anions." She then asked her students, "What forms when there is this attraction?" Dana, not getting an immediate response, pushed her fists together to demonstrate the attraction. When Dana wrote, "Ionic bonds are the attraction between cations and anions," it is likely that her ELLs did not have the English proficiency to make meaning of the statement. By pushing her fists together after asking, "What forms when there is this attraction?" she was helping her students to imagine a bond forming. The gesture was a tool to aid comprehension. For non-native speakers, this gesture should have enabled them to better understand the concept of bonding in the statement written on the Smart Board.

Another example of a gesture Dana used to teach was doing a "crisscross" cheerleading gesture to remind students about using the "crisscross" method to name ionic compounds by using rules for nomenclature. This not only served as a reminder to students and created a context to help them remember, but it also made some of them laugh. In a television interview, Jackson (2011) indicated that humor activates chemical stimulation to certain areas of the brain "so there is literally more brain to work with. There is evidence that what is humorous is also engaging and engagement is a key factor in student academic success."

Dana also used gesture to signify that her classroom was a community. For example, when Malaysia called to Dana for help, Dana responded, "I'm coming to visit. I'm making my rounds," as she gestured with her arms coming from her torso out wide toward the class. This gesture emphasized that Dana was connecting herself with her students. By doing this, she helped students to perceive themselves as being situated in a learning community.

General Verbal Encouragement.

Verbal encouragement is a type of feedback. According to Hattie and Timperley (2007), feedback, when given correctly, is "one of the most powerful influences on learning and achievement (81). Hattie and Timperley emphasize that feedback must be used in conjunction with good instruction. Feedback, they argue, is most effective when given promptly. Dana gave positive feedback to her students multiple times per class session. This example of her verbal encouragement occurred in mid-September after students had struggled to give accurate responses: "Remember guys this is just our second time looking at this, so I think you all did a great job!" Dana said this to her students after they gave varying correct and incorrect answers from a graphic organizer they had completed on elements, compounds, and solutions. Dana's response sent the message that it was okay to take risks and speak up in class, deemphasizing the "correctness" of contributions. It is important for students to learn that they are not expected to give correct answers always. Perhaps more importantly, Dana delivered the message that, after studying a topic only twice, they should not expect to understand it completely. Learning is a process, not a one-time fail or succeed activity. Dana had her students put their graphic organizers away. She reminded them about what they had learned in the previous class session. She proceeded to give them an overview of what they had learned. She then gave her students a new graphic organizer that enabled them to visualize the material in a different way. She did a "think aloud" as she modeled how to use the graphic organizer. Schiller (2007) suggests using think alouds and other metacognitive tools to aid scientific literacy. Afterward, Dana returned to asking students questions. She began with simple questions and, as they gave answers that illustrated the students' understanding, she asked more difficult questions. Because of Dana's supportive questioning sequence, the students' answers were correct. Dana gave verbal encouragement such as, "Mixtures, awesome! Yes, it is." and "Very good." Along with the verbal encouragement for correct answers, her response to incorrect answers modeled critical thinking. At one point, she had asked the class "How about salad dressing?" Damion responded, "It's not a mixture; it's a solution." Rather than responding with a "yes" or "no," Dana said, "Well, if you leave salad dressing sitting around for a while, it's going to settle, right? So you have oil, vinegar, maybe some sugar and spices in there…" Together the students and Dana discussed the complexities of salad dressing and how it could be both a mixture and a solution. Dana's interaction with her students and the content encouraged both deeper reflection and further discussion.

It was typical that, for correct responses, Dana would repeat correct answers and then add verbal encouragement such as "Very good," "That's awesome, Damion," "That's right," "Good job," "Wonderful, Tosha, you got this!" and "That's excellent, Aysha." These frequent occurrences of academic feedback are "more strongly and consistently related to achievement than any other teaching behavior….This relationship is consistent regardless of grade, socioeconomic status, race, or school setting….When feedback and corrective procedures are used, most students can attain the same level of achievement as the top 20% of students" (Bellon, Bellon, & Blank, 1992).

Dana also referred to Tyrone as being an expert on numerical value and polarity. Tyrone, at the beginning of the school year, had written, "Science is a hit or miss for me. Sometimes it's entertaining and sometimes it's boring. Exepcially [sic] when we get into chemicals and elements." The feedback Dana gave Tyrone by calling him an expert on numerical value and polarity helped to reform Tyrone's previous reflection "science is a hit or miss for me." In effect, Dana was telling him he was right in the mark…"an expert." The regular occurrence of verbal encouragement, whether it be to assure her students that it was okay to struggle with understanding new concepts or to give positive feedback for accurate responses, helped to create a classroom environment in which students could become deeply engaged.

Other Strategies and Techniques.

Dana used many strategies and techniques in addition to the ones mentioned above. Other noteworthy strategies and techniques include repetition and the use of technolgy. Dana consistently repeated students' responses when they answered correctly. Repeating served to make sure that the other students heard the correct answer. Dana used technology seamlessly to provide multiple ways for students to understand. When she made a verbal statement, she would frequently use the document camera or computer to display a visual aid on the whiteboard. In fact, the document camera or the computer was used in every lesson. Often, both the document camera and the computer were used. Students also had access to computers. Typically, they would use the computers in pairs or small groups. Occasionally, part of the class would work independently at a computer while others worked on a different activity.

Together, these strategies and techniques helped to create an environment that enabled Dana's students to move from the margins of science learning toward a science-understanding community. As Dana taught, students understood how they were supposed to complete a task because she had modeled it for them. She taught them general studying and learning skills that would enable them to access learning outside of the classroom. They also learned how to refocus their thoughts in order to prepare mentally to learn. Through the use of analogies, students learned that they could make concepts easier to understand by comparing the difficult concept to something similar that they already knew about. Similarly, they were able to learn new concepts, in part, through observing gestures Dana gave to help make abstract concepts more easily to envision. Graphic organizers were another tool she used to help her students learn. Dana gave verbal encouragement as her students participated in the learning episodes. All of these are examples of the strategies and techniques Dana used to create an engaging classroom environment.

Individual Interactions between Dana (or Bill) and Students.

Before class even started, Dana and Bill would go into the hallway and wait for the bell to ring. If the hallways were quiet, they might chat for a couple of minutes about the plans for the day, but when the hallways became populated with students, Dana and Bill would typically separate with one on each side of the corridor. Usually, Bill stood directly beside the door to the classroom and said "Hello" to students as they entered the room; although, one day he greeted Tosha and then sat next to her desk and spoke with her until class started. I don't know what the conversation was about, but Bill stayed seated next to her during the first five minutes of class. Dana typically stood against the wall across from the classroom door. There she would greet students in a variety of ways by asking them how their morning was going or whether they had had a good weekend. Sometimes she would compliment a new hairstyle or respond to a smile by saying, "I'm glad to see you are smiling today." Students would also initiate conversation with Dana by telling her that they had missed her. One student told her that she is her twin because they look just alike. Students passing in the hallway, who no longer had Dana as their teacher, would sometimes give her a hug or tell her how much they missed her. I once overheard a student telling Dana that she was the best teacher that he ever had.

At a post-observation period interview, Dana talked with me about what her intentions were during those six minutes in which students were going from one class to the other. She said that her intention was to greet them at the door in order to help them make the transition from whatever transpired in their last class to being ready to learn chemistry. If a student looked upset in the hallway, she wanted to have a minute or two to talk with him or her and help him or her leave whatever happened behind before s/he entered the chemistry classroom. If Dana had had a difficult interaction with the student in the prior day, she wanted to check in to make sure that student wasn't angry and, hopefully, would be able to get a fresh start. Dana stated that the time between classes "mostly allowed me to gauge emotional readiness. [The] check-in allowed for them to vent and for me to coach or coax them into joining me to complete the tasks for the day."

It was clear that Dana tried to interact individually with students in an equitable manner. If she started her interactions on the left side of the room one time, the next time she would start somewhere else. Most individual interactions between Dana and a student occurred when the class worked to solve problems individually at their desks; however, when students worked in pairs and small groups, Dana would work her way to all of the pair or small group teams.

Evidence of Student Engagement.

There were many ways in which student engagement was evident. I observed students taking out their notes and studying them, without being prompted, in order to complete an assignment. If the dismissal bell rang while Dana was still speaking, the students remained quietly seated. (This is also an indication that Dana was respected by her students.) Students occasionally stayed after the bell rang in order to finish something they were working on. For example, after the dismissal bell one day, Rodrigo approached Dana with his textbook and asked her a question. She explained the concept to him but then asked who his third period teacher was. She told him that she would write him a pass and directed him not to get into trouble by working on his chemistry in his next class. These examples are some of the ways in which individual students demonstrated that they were engaged.

Positive emotional climate

A positive emotional climate was the other environment that Dana created in order to move her students from the margins of science toward a science understanding community. Having a positive emotional climate, along with an engaging academic climate, created the conditions necessary for Dana to be able to build a learning community. Having an engaging academic classroom is interconnected with having a positive emotional climate. In fact, it is difficult to conceive of a classroom in which students are academically engaged without also being in a positive emotional climate. In many ways, having a positive emotional climate enables students to become engaged. Engagement requires participation and participation and "is a complex process that combines doing, talking, feeling, and belonging. It involves our whole person, including our bodies, minds, emotions, and social relations" (Wenger, p. 56). Below are examples of some of the ways in which Dana created a positive emotional climate.

Positive Relationships.

There were many ways in which Dana built positive classroom relationships. The verbal politeness that Dana showed her students demonstrated that she liked and respected them. For example, she often said "please" and "thank you." When a student offered her periodic table for Dana to use, she responded by saying, "Thank you, Dear."

The word "let's" means "let us." It implies "us" as a group including the speaker. Dana used this term frequently. In fact, on one occasion, she used the word at least six times in a single class period. She began the lesson by saying, "So let's go on and talk about physical versus chemical properties and let's do that on the double bubble." Later, as a transition, she said, "Then on the other side let's do chemical properties…" Afterwards, to compare physical and chemical properties, she said, "So let's switch, let's go over and look at how chemical and physical changes differ." To let students know that they weren't going to be doing this activity much longer she said, "Let's go over this quickly and then move on.…" Dana's frequent use of the word "let's" makes students feel as if they are a community working together with their teacher. This is one way in which Dana established a positive emotional climate that would help her to build a learning community.

Another way in which Dana created positive classroom relationships was by taking the responsibility herself rather than laying it all on her students when many of them didn't turn in an assignment. She told her class, "I don't think I asked for it in the right way since only two people turned it in. You are going to need to turn it in, but it's not hurting you right now because I don't think I asked for it in the right way." Her statement communicated that she was able to accept that she may have made a mistake in how she gave the assignment. Her being able to accept responsibility for her students missing the assignment modeled for the students how to accept responsibility. It also communicated to them that she was fair. The way in which Dana handled this situation was very respectful of her students.

Dana was also able to empathize with students when they expressed their needs. One day a student complained that she was hot. Dana told her that she also was hot. At the beginning of October, Dana told her class that she knew they were tired because of HSA testing and that some students were missing due to the testing. Therefore, they were going to have a modified lesson that took into consideration the impact of the HSA testing. Dana also used empathy when she was motivating her students to try. For example, during one class session, Jeremiah had his head down on his desk. Dana said, "Jeremiah, you gotta wake up. You're missing a lot of stuff here. I know this is dry and people are hungry. It's Monday. We gotta get this." Here Dana expressed many reasons why the student may have felt like putting his head down but encouraged him to try because it is important (you're missing a lot of stuff). Dana's use of the word "we" communicates that they (the class) are in this together. Her use of "we" encourages community similar to the term "let's" that was discussed earlier (see above). Furthermore, the empathy she showed students gave them affirmation that she respected and cared for them.

Another example of Dana creating positive classroom relationships took place on one day when Dana called on Tyrone:

> "Tyrone, you ready?" He didn't respond, but appeared to be trying to figure out the answer. Mark raised his hand, indicating that he would like to answer. Dana replied, "Wait a minute. We are going to wait for Tyrone to respond." While Tyrone worked on the problem, she went to Tavon, looked at his work and spoke with him briefly. Then she said, "Tyrone, would you like *us* to come back to you?" Tyrone said, "Yes."

By interacting with her students in this way, Dana made sure that Tyrone felt respected. He was given the time that he needed to work without being made to feel that he could not participate due to the speed at which he was able to produce a response. Furthermore, Dana's use of the term "us" shows, once again, that the class was a community working together as a whole.

Teacher Shares Personal Science-Related Stories with Students.

Sharing personal narratives helps teachers to create positive relationships with their students. According to Collins and Cooper (2005) "This relationship building can occur when the teacher tells a story about himself. It may be the first inkling students have that this teacher is a real person, one who grocery shops, goes to the movies, has fears and frustrations. This sort of knowledge is what builds relationships" (p.14). Holladay (1987) asserts that teachers who use storytelling are more effective than those who do not (p. 6).

During the academic year, Dana revealed her own experiences of people attempting to marginalize her because of her race and the demographic area where she grew up. By sharing those personal narratives, she shared part of her identity with the students. Before sharing the narratives, students had no way of knowing how she grew up or what types of obstacles she faced. Through the sharing of her experiences, students could imagine who she was as a young adult who had been raised in the Mississippi Delta. Perhaps some students had similar experiences that they were reminded of as she spoke. Others may have been told other stories of African Americans struggles, especially those who came from poor backgrounds. Yet, other students may have been made aware of their privilege as they learned of her hardships. Although students came to Dana's class with very diverse backgrounds and identities, her personal science-related stories helped all of them to perceive themselves better as becoming members of the science-understanding community. Either they were able to identify with Dana's struggles or they were able to identify themselves as being comparatively privileged.

It is worth noting that these stories may have further helped students who recently immigrated to the United States to situate their identities within the American science-learner context. Dana's students coming from other countries may not have realized the intricacies of the types of struggles that can occur in the U.S. before hearing her stories. According to Wenger (1998), "we define who we are by negotiating local ways of belonging to broader constellations and of manifesting broader styles and discourses" (p.

149). While students coming from other countries came to the United States with identities that included an understanding of who they were and who they were not within the context of their native land, in many ways their identities were renegotiated in their new environment. As they heard her stories, their internal narrative compared and contrasted their identities with hers helping them to place themselves as science learners (with degrees of privilege or lack there-of) within the American context.

No matter the background of the listener, one could not help but be affected by Dana's powerful stories of individuals who gave her the message that she was not supposed to obtain an accomplished career. Dana was able to rise above these low expectations and she made it clear that her students had the ability to equip themselves with knowledge so that they would not be marginalized by others. Below are examples of personal narratives that Dana shared with her students.

A student asked Dana to make her explanation more simplified. Dana responded by saying, "Dude, you want me to speak to you as though you were simple?" She explained to the class that part of learning science is to be informed citizens. She continued to share two personal stories that served as important life lessons. First, she shared about getting a new asthma prescription for her daughter when her daughter was five years old. When she went to pick it up from the pharmacist, she asked him to tell her about the new prescription. He replied, "Oh, you wouldn't understand." She responded, "I have two degrees in biology, I certainly will understand."

After telling this story, Dana told her students a counter story—one that would serve well to illustrate what might happen if they don't get the science education they need to become informed citizens. She prefaced the second story by telling them, "I would be insulted if someone spoke to me as if I were simple." She went on to tell her students that when she was a teenager her grandmother would take her to her doctors' appointments because her grandmother said that the doctors speak another language that she didn't understand. Dana told her students that they don't want to go through life not being able to access information. She brought this important life lesson to a close by stating, "I am not going to speak to you all as if you are simple."

For students who often think that the goal of taking a class is to get a good (or, at least, a passing) grade, Dana's stories helped them to see beyond the grade by thinking in terms of how learning chemistry would help them become informed citizens who are capable of understanding their doctors and pharmacists. Students wouldn't have to think about it much to realize that being able to understand their doctors and pharmacists also meant they would be able to understand the effect that the treatment/medication was supposed to have on their body. Dana's stories gave students a reference that could help them change the paradigm from taking chemistry to achieve a certain grade (or even to get accepted to a certain college) to learning chemistry to gain valuable knowledge in order to navigate society independently. Further, Dana's stories contrast herself, one who belonged to the science-understanding community, with her grandmother, one who did not belong to the science-understanding community. It is clear by her statements, "I would be insulted if someone spoke to me as if I were simple" and "I am not going to speak to you all as if you are simple" that she perceives her students as either being or becoming members of the science-understanding community. Therefore, the stories told together, as a response to the student's request for a simplified answer, acted as an affirmation that they are not students on the margins of science learning.

Dana used the power of stories in all of her relationships, much to the benefit of her students. Stories transcend all classes and cultures; they are both international and transhistorical (Barthes, 1977, p. 79). According to Barthes (1977), narratives consist of five codes that are woven together. One of those codes is the cultural code which is based on the premise that humans from all backgrounds have shared knowledge about the way the world works. As Dana shared her stories, she was giving her students the ability to make connections between their narratives and hers. In other words, she was building a bridge to help students in their ability to relate to American ways of perceiving the sciences. Lee (2005) asserts that students who have cultural beliefs that are "discontinuous with Western science should be instructed in a manner that enables them to cross cultural borders between the two domains" (p. 503). Dana's telling of powerful stories about her lived experiences with science is one way of enabling her students to cross cultural borders.

Here is another powerful story that Dana shared after being asked about whether she had seen the movie *The Help* that had just come out in theaters:

> "That was how the Delta Mississippi was," she said. "If you were African American, there were assumptions about who you were." She told us about when she gave birth to her first daughter and the nurse asked how many years of education she had. Dana was in her last semester of college so she said "15 ½." The nurse said, "No, I'm not asking your age." Then the nurse was complaining about how Black men don't stick around to help raise their children. The nurse was surprised when Dana's husband walked into the hospital room while they were talking. She said in the Delta Mississippi, if you were Black then there were

> assumptions about what you could and couldn't do—no matter what kind of education you had. She went on to tell about how one woman, who later became her mother-in-law, worked at a chicken factory and told Dana she should get a job there. Dana told her that maybe she could work in the science department there. But the woman said, "No, not that." She was expecting Dana to cut up chicken even though she had gone away to college and had a degree in biology!

Dana's stories about her experiences in the Delta Mississippi and the assumptions that were made based on her African-American heritage and demographic origin demonstrate her knowledge of the discrimination that exists coming from the science community as well as from within her own community. It is clear, from her sharing these stories and her choosing to share personal stories of the marginalization of her grandmother and of the pharmacist attempting to marginalize her, that she is trying to equip her students with the knowledge they need to not be marginalized in relation to the science-understanding community.

Dana wasn't the only one who was able to make the connection about chemistry being valuable knowledge that could be useful in life. The following example demonstrates that students were able to make the connection between learning science and becoming part of a science-understanding community. One morning, the class was learning about molecular compounds that result from covalent bonds. Rodrigo told Dana that she should make up her own solutions at home. Dana replied by explaining that the vet had shared with her the solution recipe for a medication for her dog's ears. Knowing how to make the solution properly saved her a lot of money because the medication costs $40 per bottle.

The moral of these stories is: if you learn science, you will become part of the science-understanding community rather than being marginalized and even oppressed by those who are educated about science. Her narratives sent a very clear message that Dana cares about her students and wants them to become scientifically competent in society.

Conclusion

This chapter has shown how Dana laid a foundation for science learning by creating an engaging academic classroom and a positive emotional climate. As illustrated in Figure 4, this environment, shown as the first circle inside "The Margins of Science Learning" enabled Dana's students to move from the margins of science learning toward a science understanding community. It also created the environment necessary to build a learning community. The following chapter discusses how Dana continued to create an environment which would enable students to move further toward a "Science Understanding Community" (the center of the concentric circles in Figure 4) by "Building a Learning Community" (the third concentric circle in Figure 4).

Chapter 5:

Building a Learning Community with Funds of Knowledge

The previous chapter revealed the ways in which Dana created an engaging academic classroom and how she cultivated a positive emotional climate. Together, these characteristics laid a foundation that enabled her to build a FofK learning community which would further act to move students toward becoming participants in a science-understanding community (see figure 4). In order to build a learning community, Dana 1) used inclusive language, 2) engaged students in learning episodes, 3) incorporated students' FofK/identity into the chemistry content, and 4) encouraged community among herself and students. This chapter discusses how Dana implemented these four characteristics to create a learning community. This chapter concludes with a discussion of how the second concentric circle ("Engaging Academic Classroom" and "Positive Emotional Climate") and the third concentric circle ("Building a Learning Community") enabled students to move from the first concentric circle ("The Margins of Science Learning") toward the fourth concentric circle which is beginning to emerge as members of a "Science-Understanding Community" within American society (see Figure 4).

> The defining quality of a learning community is that there is a culture of learning, in which everyone is involved in a collective understanding. There are four characteristics that such a culture must have: 1) diversity of expertise among its members, who are valued for their contributions and given support to develop, 2) a shared objective of continually advancing knowledge and skills, 3) an emphasis

on learning how to learn, and 4) mechanisms for sharing what is learned (Bielaczyc & Collins, 1999, p. 2).

Dana's use of words such as "let's," "us," and "we" serve to include *everyone*. She continued to use these types of speech acts throughout the time that this study took place. Another example of a way in which she worked to ensure that "everyone [was] involved in a collective understanding" (p. 2) was observed when she took measures to ensure that Tyrone was able to participate rather than being skipped over when a faster responding student offered to solve the problem (see Evidence of Teacher Building Positive Classroom Relationships). Affective dimensions of learning, such as feelings of group affiliation and solidarity, are important in creating effective learning communities. According to Hall (2002), "some communicative resources for doing so include the use of respectful, affirming responses to student contributions, and of personal pronouns such as 'we' and 'us.'" Affirming responses to students' contributions were seen throughout the data (see above General Verbal Encouragement discussion). These are a few examples of how Dana made her students feel they were part of a learning community.

Learning Episodes

For the purpose of this study, a learning episode is when multiple students were actively engaged in learning a concept or learning objective together. In the lesson described below, the students played a teacher-led game during the last thirty minutes of class. Below are the details of how the game was played:

> Students grouped themselves into four teams of four players. Dana told them that each team would have to come to a consensus about the correct answer for each multiple-choice question. Each team was provided a small white board and dry erase marker. It was explained that when teams earned points, they would receive school bucks that could be used at the school store to purchase school spirit items or school supplies. Dana showed them some examples of items for sale at the school store. Dana began the game by asking, “All right, what is the independent variable? What is it?” One group held up a white board with a “D” written on it. Then, the other groups held up their whiteboards all with letter “D.” Dana responded, “All right, we have to set some ground rules.” Antonio, from the group who put their whiteboard up first, stated, “Whoever has it up first, should get the points.” Dana said, “So you guys want it to be the first group or everyone who gets the answer, gets points?” Some students said they wanted it to be the first group. Dana used the rule her students established. The game proceeded, “Okay, I saw group four first,” Dana said. By the end of the game, each team player had earned bucks to spend at the school store.

There was a lot of talking and excitement among the groups as they competed to have the correct answer first. Even students who tended to be quiet in class were smiling and participating. Aysha, who rarely spoke in class, walked out of her way to give me a high five after she collected her bucks. The game provided a way for all students to participate through small group collaboration in a way that is similar to a think-pair-share; however, the interactions took place very quickly since it was a competitive game. During the game, students were able to make the rules rather than Dana. This helped to form a community of learners; students had a voice in how the activity would proceed. Dana facilitated the game, but the rules of the game belonged to her students. By stating, "Whoever has it up first, should get the points," Antonio demonstrated that he knew he had a voice in Dana's class. Otherwise, he would have waited for Dana to tell the class what the rule was. Students who know that they have a voice in the classroom feel valued. When the classroom emotional climate is one in which students feel valued, an environment exists where a community of learners can develop.

Another example, took place in which at least seven of 15 present students verbally participated in a large-group learning episode on naming and writing formulas for iconic and molecular compounds using rules of nomenclature. In another, 12 of 16 present students actively verbally participated in a lesson on classifying the five types of chemical reactions by identifying their reactants and products. Three of the 12 students had not been verbally participating in the beginning of the lesson, but Dana was able to engage them by asking them questions and providing verbal encouragement when they responded.

Encouraging Funds of Knowledge/Identity

As a result of the professional development provided to Dana during this project, she taught three units that specifically included SCFofK. These units included: Alloys, Nomenclature, and Mass.

Alloys

The unit on alloys was the first of three units that Dana developed to connect her students' identities to the chemistry content of the course. To begin, Dana told the class they were getting a homework assignment on alloys that they use in their home. She made a poster to model an example and used it to demonstrate as she explained, “I did my poster on warm combs. In my family, the process was....This is the part that is the most important to me.”

Dana continued, “The iron ones you pull through and you get this nice pretty hair. With the brass ones, you pull it through and you pull...” Dana motions with hands near her hair and has a facial expression that conveys discomfort. She continued, “and you get hair breaking and...so I threw my brass ones away. This is my grandmother; this is my aunt Dana.” Dana points to pictures on her poster as she speaks. “This is my rebel aunt here. She’s got a fro...My mother and grandmother did hair on Sunday evenings.” Dana continued to talk about the family tradition of the women and girls in her family talking and doing one another’s hair on Sunday evenings while the men and boys worked on vehicles or watched sports. Dana told her students that Sunday evenings were a time when she got her hair done and talked with her mother and grandmother for what seemed like hours. “When I got older, I stopped doing this and grew dreadlocks and my daughter has natural hair.” She referred to the warm combs shown on her poster and said, “This is an item that is near and dear to my heart. So when you guys choose something, make sure you choose something near and dear to your hearts too….”

As Dana used her poster to tell her story, she was, again, sharing her out-of-school identity with her students. The story of her connection with the iron alloy used to make warm combs not only served as a model for how students were going to present their alloy, but also helped to build her relationship with her students (see Teacher Shares Personal Science-Related Stories with Students, above). After she shared her story, some students commented that they never would have imagined that she had dreadlocks.

Dana's telling students that she had dreadlocks and that her daughter has natural hair tells her class much more than two facts about her family's hairstyle choices. Dreadlocks and natural hair (such as an Afro) became political statements associated with the Black Power Movement in the 1960s and 1970s (Tate, 2007). By telling her students this, she was revealing her political identity through her use of black anti-racist aesthetics.

Similarly, as her students presented their alloy FofK projects via a gallery walk, they shared information about their identities. The wide variety of FofK projects demonstrated that students had many areas of knowledge that are traditionally not discussed in high-school chemistry. Among the topics that students felt were "near and dear to their heart" were:

- technology components (that are found within computers, cell phones, iPads, and SLR cameras);
- cookware (including iron skillets and stainless steel pans);
- jewelry (including gold, sterling silver, and nickel);
- small appliances (including clothes irons, flat irons, and rice cookers);
- sporting goods (including cleats, baseball bats, and lacrosse sticks),
- musical instruments (including guitars, snare drums, bass drums, tom-toms, symbols, and flutes);
- collector's items (including die-cast toys and coins); and
- metallic nail polish, orthodontic braces, and tire rims.

It's worth noting that many students went well beyond the requirements of the assignment. For example, Elijah, who loves to play a variety of instruments, wrote a report on four instruments rather than just doing the one that was required. He included a picture of himself playing a marching snare drum, which he wrote about before continuing on to include pictures of and write-ups for his concert snare drum, symbol, and tom-tom. When he talked about the alloys used in the rim of his drum, Bill, who is also a musician, commented about how that alloy will produce a different sound than other types of drums. This led another student, who plays a bass drum, to comment about the sound of his drum and how it is probably because it is made with a different alloy (although his project was on tire rims).

At the end of the unit on alloys, Dana stated that her students were so much more engaged in this project than her students had been in the past. She also mentioned that she had used this project with her honors class just to see how they would respond. They were just as engaged as the students in this class. She confirmed that she would continue to use a FofK project to teach alloys in the future.

Nomenclature

When Dana introduced the unit on nomenclature, her first step in encouraging students to share a story about their identity was, again, sharing her own. The above discussion on how Dana shared her personal science-related stories with students details how she shared her identity with students. These stories also served as a model for students to share their stories. For this unit, Dana began by asking her students to share a story with a peer. Upon entering the classroom, students saw the following instructions projected on the whiteboard:

> **Today's Drill:** Turn to your neighbor and tell her/him your name and the history of your name. (For example, my name is …. My first and middle names are the same as my mother's youngest sister's. My maiden name is my father's last name. The name… is my husband's last name.

Dana began class telling her students that they were going to love the drill and asking them to turn to a neighbor to share the history of their family name. A great deal of discussion followed. Afterward, students were invited to share with the class. Below are three examples of what they said:

> "I am named after my two grandmothers ." --Maria
>
> "My last name changed over the centuries. It was Johnson, then...now it's [last name]. They changed it because, all right, my grandfather's family, I guess they used to be in slavery.... So they changed it because he was against slavery and I'm 25 percent White." --
> Jeremiah
>
> "My grandfather cared about my grandmother so much that he took her last name. I know Jamal means 'mighty beyond measure.' My father is from Jamaica."
> --Jamal

Dana then used these stories to explain the periodic table. For example, Rodrigo stated his full name (which included both of his parents' last names). He explained how in his culture, children keep both parents' last names. He also explained that he has the same first name as his father. Dana said, "Father's first name, okay. Very good. So, Gomez is father. Gonzales is mom. When you look at last names, can you maybe tell where the person is from?" Dana continued, "Last names can tell us where people are from. I know a Johnson when I meet one. There are certain characteristics. I know I have certain characteristics in common with my brother. She talked about immediate family characteristics and extended family characteristics and how she has some things in common with her cousins. Jeremiah added that he and his sister are the last people in the family so he needs to have some babies. Dana then talked about the characteristics of elements of the periodic table and how you can recognize the "families" of elements based on their characteristics.

Dana continued relating her students' stories as she explained nomenclature concepts. For example, she said, "I just like how Jeremiah said that they changed that name to Johnson, right?" Jeremiah nodded. Dana continued to explain that many last names don't change; they stay the same, but sometimes, under certain conditions, they change as is the case with Jeremiah who knew that, at some point in history, his family's last name changed. When she didn't have a student from that class to use as an example, she used a name from another class to make the connection. For example, Dana referred to the class outcome posted on the whiteboard and told a story of how, in a different class, there is a Wendall and his family has a Wendall the 1^{st} ,2^{nd}, and 3^{rd}. She explained that it is the same with cations.

After class, Dana told me that she again used the SCFofK name activity with her honors class. She felt that her students in that class increased their responsiveness during the lesson. One student, who typically would not speak up in class, talked about how her middle name is Amanda and how she has the same middle name as her grandmother. Dana emphasized that Amanda has "never talked and never responded" to Dana's questions in the past, but for this activity she stood up with her cheerleader stance and spoke proudly. Dana was smiling broadly as she told me this story, recognizing that her efforts to include FofK pedagogy was effective for all students, not just those placed in her low-performing class.

Dana's students really engaged well with this activity. Both she and Bill reported during this lesson, Rodrigo spoke up more than ever before. Similar to the Alloy unit, Dana plans to use this activity to introduce nomenclature in future classes.

Mass

Dana began the unit on molar mass by having her students complete an activity called *How Much Carbon is in My Masterpiece?* Students were given a piece of charcoal and a large sheet of plain paper. Written on the Smart board was: "Your task today is to determine the amount of carbon used to create a work of art." Dana stated, "So today you are going to measure the amount of carbon used to create your work of art." She then showed the class her work of art that she created and posted on the cabinets. She shared the stencils she used in her drawing and showed them the stencils she had available for them to use. She also introduced the charcoal they were going to use. Dana asked her students, "Are we measuring volume?"[4] Some students replied, "yes" while others replied, "no." One student calls out, "No, we are measuring mass." Dana repeated what the student said and then asked her class, "Do you think we can get all the way down to atoms?" Again, some students responded, "yes" while others said, "no." Dana then told them that their drawings had to use the whole page because the scales they had

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[4] Earlier in the class they had discussed favorite recipes and how they would measure the different ingredients in the recipe. They had also discussed how one could measure the amount of paint used to paint a wall. In asking the students about whether they were measuring volume, Dana was assessing to see whether they comprehended the previous class discussion and whether they were able to apply it to a new problem.

were not sensitive enough to measure the charcoal used for a little stick figure drawing; they had to really use their charcoal.

After about 10 minutes of drawing, students were prompted to finish this part of the activity. Dana circulated around the room interacting with her students by giving positive remarks such as “That’s cool. That’s really cool!” or briefly speaking with them about their drawings. After five minutes, students were directed to re-weigh their charcoal, calculate the mass, write the mass on a Post-it and place the Post-it on the corner of their drawing before posting their works of art on the cabinets. First the class identified which drawings had the most and least amount of charcoal mass. Afterward, Dana encouraged but did not push her students to share what their drawings were about. Many of her students were eager to tell the class about their drawings. James, for example, had drawn a cartoon. He explained his cartoon to the class and used different voices to act out the story, which he said took place in New York. Isaac also wanted to share. He told the class that his drawing reflected his love of trains and the ocean and also because the picture is from a cover of a favorite record album that he had in his collection. These are just two of several examples of students who shared their drawings with the class.

This activity was used as part of the introduction to mass. It taught students how to calculate mass in a way that was both clear and interesting. After this part of the lesson, Dana went on to use a bridge map to teach more complex aspects of determining mass. This drawing activity, although it served to introduce the concept of mass, also served to build a learning community in several ways. According to Wenger (1998), “[A] community of practice is a living context that can give newcomers access to competence and also invite a personal experience of engagement by which to incorporate that competence into an identity of participation" (p. 214). Although James and Isaac came to class regularly and were usually on task, they were not students who typically volunteered answers during large-group discussions. Both students had IEPs for learning disabilities and seemed to take a great deal longer than most students to respond to Dana's questions. Yet this activity enabled them to participate fully in the introductory lesson on mass. As they shared their drawings, they were completely competent in sharing their personal experience which was derived from their out-of-school lives. Through their eagerness to share, it was evident that they were engaged as they incorporated their identities and chemistry content.

Encouraging Community

Collaboration is an important part of establishing integrating students' FofK in a learning community. Cummins (1996) postulates,

> [Students] are empowered through their collaboration such that each is more affirmed in her or his identity and has a greater sense of efficacy to create change in his or her life or social situation. Thus, power is created in the relationship and shared among participants. The power relationship is additive rather than subtractive. (p. 16)

Building upon the example from above, James and Isaac were able to build power as they shared their FofK as they presented their molar mass drawings to their class. This gave the learning community another means to connect chemistry content with James' and Isaac's out-of-school lives. It also gave the others in the learning community the ability to know James and Isaac better and to think about commonalities that they might share. For example, it is very possible that other students had experienced New York. We know that at least one other student liked trains because she did her alloy project on the train set her grandfather had given her. It is also very possible that Dana would be able to draw on James' and Isaac's experiences to help them with other complex chemistry concepts.

When Dana and I met to discuss lessons, she would often comment about how she was still trying to get certain students to verbally participate in class. For example, Rodrigo was a student who worked hard on his assignments and would come to her when he had questions, but he resisted speaking when the class was engaged in a large-group discussion. Dana revealed that she believed he lacked confidence in his English language ability. To help Rodrigo overcome his language barrier, she encouraged him to work with Maria, a bilingual student who was fluent in both Spanish and English (see A Community of Voices for further discussion). By reflecting on her students' class participation, Dana was able to consider ways in which she could encourage the students to work together as a community. By allowing Rodrigo and Maria to use their native language, Rodrigo was given a voice since he often did not demonstrate the ability to discuss chemistry in English. By encouraging Rodrigo to work with Maria and allowing them to use Spanish, Dana gave Rodrigo the ability to move from the margin of learning chemistry into the community of learners. In this case, Maria provided the language bridge he needed to participate. Both were empowered through the collaboration as it affirmed both of their identities.

Similar to the way in which Dana encouraged Maria and Rodrigo to work together, Dana frequently asked one student to help another. For example, a few students were waiting for Dana to help them convert between mole, mass, and number of particles by using a mole map. A fourth student requested help. Still busy, Dana said, "Amara, you could help, right?" Some teasing follow when Amara responded, "I COULD." Dana smiled at her and said, "And you're such a generous person." Amani helped Trevor and then asked the class if anyone else needed help. Dana's intention to draw Amara into the learning community was successful, Amara later offered to assist others on her own initiative.

Another example of ways in which Dana encouraged community was demonstrated earlier when the students were able to decide upon the rules of the game. Dana acted as a facilitator rather than the one who ran the game. This enabled the students to negotiate rules and decide how they wanted to play the game.

Conclusion

This chapter has demonstrated the ways in which Dana's students moved from a position of being institutionally marginalized to 1) becoming engaged in learning science, 2) becoming part of a learning community within their classroom and 3) moving toward an epicenter in which citizens are members of a science-understanding community (see Figure 4). Although each section was written as if it were separate from the others, there were no clear lines of distinction between one section and another. For example, Dana's engaging academic classroom was intermeshed with, not separate, from her positive emotional climate. Likewise, these climates were part of the learning community. Although the learning community could not have existed without the pre-existence of an engaging academic classroom and a positive emotional climate, the learning community would not have been sustainable without the continuation of the established environment.

As the study came to an end, Dana's students were beginning to emerge as members of a science-understanding community within American society. Taking chemistry, for these students, meant much more than passing the class; it meant being able to use science in life.

Chapter 6

Conclusion: What We Can Learn from Dana's Classroom

The implications for this study are 1) that teachers need to bridge the gap between where students are and where they need to be in order for them to become part of the science-understanding community; 2) stories play a significant role in enabling students to move from the margins of understanding science to the epicenter of the science understanding community; 3) students' identities need to be incorporated into the science classroom; 4) mandated testing and gateway courses creates a "jumping through hoops" focus rather then developing students love for learning; and 5) professional development for SCFofK should be provided only to those teachers who have already demonstrated effectiveness in creating a classroom environment conducive to implementing a student-centered funds of knowledge approach. Below, I summarize the results of this study and then discuss these implications in further detail.

The purpose of this study was to explore how we can better apply sociocultural learning theory to connect students' identities with secondary science content. This inquiry was conducted as a collaborative study designed to answer the following questions:

3. How does Dana build a learning community that incorporates students' FofK (FofK)?

    - What strategies and techniques does she use?
    - How does she create an engaging classroom climate?
    - How does she build a community of learners?
    - How does she incorporate students' FofK/identities with the chemistry content being taught?

4. What are the implications of creating a learning community that incorporates students' FofK in the chemistry classroom?

In an effort to describe how Dana built a learning community that incorporated students' FofK/identities with the chemistry content being taught, I analyzed field notes that were taken from 11 observations over a period of five months. In addition, I used field notes from a series of formal and informal interviews, and audio recordings of unit planning sessions in order to gain insight into the connection between student identity and secondary chemistry content in a diverse classroom. In this chapter, I summarize the findings discussed in chapters four and five before describing their limitations. I then discuss possible implications for educational practice. Finally, I consider some possible implications for future research.

Summary of Results

Sociocultural learning theory (SCLT) situates learning in a "space" that includes the social interactions of the student both in and out of school. The examination of the data from this study revealed that, when students have an engaging academic classroom and are in a positive emotional climate, the conditions are set for a skilled and caring teacher to build a learning community with FofK. This learning community is paramount in moving students from the margins of science understanding toward the epicenter of a science-understanding community.

Analyzing the ethnographic field notes from observing Dana's classroom revealed that Dana built an engaging academic classroom by 1) modeling for her students how she solves chemistry problems and completes lab tasks; 2) teaching them general studying and learning skills that they can use not only for chemistry, but to help them with anything they want to learn; 3) using analogies to help students make sense of abstract concepts; 4) using gestures that aid students', particularly ELLs, comprehension; 5) giving general verbal encouragement; and 6) using basic strategies and techniques such as repetition and the use of technology. In addition, Dana and Bill frequently engaged in individual interactions with students. Student engagement was evident by observing students consistently: 1) taking out their notes and studying them without being prompted; 2) remaining academically engaged in their seats after the bell rang if Dana was still speaking; and 3) occasionally staying after class in order to finish what they were working on even though Dana did not encourage her students to stay after class.

Analysis also shows that Dana took several steps to create a positive emotional climate. These steps included: 1) having positive relationships with students as was evidenced through verbal politeness and inclusiveness; 2) taking responsibility herself rather than blaming students; 3) empathizing with her students; 4) waiting for students who needed more time; and 5) sharing personal science-related stories with students. By taking these steps, Dana strived to ensure that her students would feel that they were cared about and would be emotionally safe to engage academically.

The engaging academic classroom and positive emotional climate that Dana created set the conditions for Dana to build a learning community. Dana built a learning community through 1) engaging her students in learning episodes; 2) encouraging her students to connect their FofK/identities with academic content; and 3) facilitating a learning environment in which her students shared their knowledge and experiences with one another.

Using students' FofK strengthened the learning community by 1) giving students the opportunity to share their knowledge and experiences from their out-of-school lives with one another; 2) this, in turn, leading to students having new connections with their classmates; and 3) enabling students to recognize a variety of real-life applications of the academic content being learned in class, which countered the notion that the goal of learning is to achieve a grade (or to graduate from high school or to get accepted into college).

At the beginning of this study, Dana's students had been institutionally positioned in the margins of understanding science. This is evident by how they were referred to by their school Principal, as students who "would not typically take chemistry in high school." Yet, with an engaging academic classroom and a positive emotional climate, Dana was able to build a learning community that moved her students toward the epicenter of science learning.

Discussion

In an increasingly diverse society, it is the job of educators to make sure that public education is equitable. The discussion that follows addresses key ideas stemming from this study to help insure that secondary science education gives all students the support they need to move from the margins of science learning in order that they may become members of the science-understanding community.

Bridging the Gap.

Dana used several means to bridge the gap between where her students were and where they needed to be in order to become part of the science-understanding community. A major reason why she was able to teach her students successfully was because she did not make assumptions about what they knew and what they did not know. She was careful to share with them basic studying and learning skills while also knowing that they were coming to class with experiences and knowledge that were unique and valuable. Like a viaduct carrying information in both directions, Dana shared her FofK regarding science and learning, while students shared their FofK. Over the course of five months, sharing took place and was built upon in order that a learning community was formed. This is true learning; learning is not memorization of facts for the sake of getting a decent grade on a test. Students, when participating in a FofK learning community, are much more likely to remember the material long-term. Perhaps more importantly, they are likely to have a positive feeling about the subject matter so that they will want to continue the learning even after the course is completed. Steps should be taken to ensure that students are given the opportunity to participate in learning communities that incorporate students' FofK.

Stories Bond and Create a Point of Reference

Stories play a significant role in enabling students to move from the margins of understanding science to the epicenter of the science-understanding community. As Dana shared her powerful personal stories with her students, they were able to envision where she positioned herself in society as a human being. She was no longer a teacher with no out-of-school identity. Through her sharing, her students learned that where she grew up, in the Mississippi Delta, African Americans were subservient to Whites and women were subservient to men. It was as if there were an invisible boundary used to keep her confined in the margins of society. Her students learned that as Dana moved toward the epicenter of the science-learning community, many in her community did not recognize that her identity had changed. Society still perceived her as unable to make good choices, unable to understand science, and unable to participate as a science professional. Dana pushed back against the oppression by assuring the pharmacist that she absolutely would understand his explanation. She pushed back against members of her own family by getting a job as a scientist in Chicago rather than becoming a chicken-factory worker. And she pushed back on a larger scale by sharing her stories which modeled for her students how to overcome racism and sexism. Beyond just overcoming discrimination, Dana's stories paved a pathway enabling them to envision themselves surmounting their confinement. She modeled for them how they, too, could move from the margins of science learning toward the epicenter of the science-understanding community.

Dana's stories also gave a point of reference that could help students who were new to the state (or the country) situate themselves in their new community. Through her stories, she revealed that she had been marginalized in a way that was likely similar to many of her students' own marginalization. Now her students knew she had experienced living in a society that made assumptions that were completely disconnected from what her FofK actually were. Whether they were African American, African, Hispanic, Asian, Middle Eastern, or otherly-abled (mentally, emotionally, or physically), her students were able to identify with her oppression. They recognized that one can be from a different culture or set of circumstances, yet face very similar obstacles.

Identity Belongs in Science

Science has long been considered a subject in which one should leave his/her identity at the door. From the time I heard a student list off the ingredients of a favorite recipe when asked about mixtures and solutions in his chemistry class and then say, “down south lip smacking goodness,” I knew it was wrong to frown upon the idea of students connecting their identities in the science classroom. When science is not connected to our identities, it remains difficult to understand because there is no way to relate the concepts to what is important to us.

For students who do not have a family member or close relationship with a science professional, they are much less likely to relate to science unless they have a teacher who builds a FofK learning community through which students feel they belong. In order to diminish the longstanding domination of white males occupying the sciences, teachers—no matter their race or gender—must teach using a FofK approach. This will help ensure that students are able to recognize science applications in their daily lives and, as they investigate the applications that interest them, they will be able to envision themselves as scientists.

It is common for teacher educators to profess that a “good” teacher must activate background knowledge, but activating background knowledge often further perpetuates white dominance in the sciences. This is because activating background knowledge generally relies upon the teacher using his/her knowledge to determine how to activate the students’ background knowledge. By doing this, the students who have a background that is similar to the teacher are much more likely to have their background knowledge activated. Activating background knowledge is commonly done with topics that are very familiar to certain groups of Americans. When facilitating professional development in STEM content areas, I have observed teachers using topics to activate background knowledge that clearly favored some cultures or genders over others. For example, topics such as skiing, baseball, football, and military life, will clearly engage some students and not others.

By using FofK, students are able to connect their own identities to the science content. As they do this, science becomes part of them, transforming them from being in the margins of science learning to participating in the science-understanding community.

Jumping through Hoops Isn't Learning

In recent decades, mandated testing has been a high-stakes issue for some science subjects. Biology, for example, is often taught as a tenth-grade subject that requires a high-school assessment (HSA) in order to earn a high-school diploma. At the school where this study took place, students who failed the Biology HSA twice were encouraged to complete a Biology project instead. In order for the project to be accepted in lieu of the HSA, it had to meet strict criteria. Since these projects were not part of a class, students, for the most part, worked on them independently. According to Dana, these projects were so difficult that many students would not complete them. Sadly, without passing the HSA or the project, students would not be permitted to graduate from high school.

Although chemistry often doesn't have a high-stakes assessment, it is typically considered to be a gateway course for college admission. Therefore, in order for students to attend a four-year university—no matter what they plan to study—they must first pass the biology HSA and then pass a high-school chemistry course. This often creates a high-school science program that is too focused on jumping through hoops rather than developing a love for learning.

Students love to learn when they are able to connect the subject matter to their identities. In their work, Shelton and Altwerger (2015) identify "a true participatory learning environment" as one that "locates agency, power, and control in the hands of the participants themselves" (p. 43). They further affirm that "[student] literacy proficiencies should enable them to engage in practices that are personally relevant and meaningful" (p. 61). Drawing on students' FofK is a very practical approach connecting students' identities to science content. However, when teachers are made to focus on preparing students for high-stakes testing and completing high-stakes projects, there isn't much time available for implementing students' FofK. Yet, FofK is where learning takes place. According to Smith (1998), testing creates an environment in which students and schools are forced to be competitive. He continues:

> Memorization is emphasized, the inevitable forgetting is ignored, and no attention at all is paid to what students actually and permanently learn about themselves and education…. Teachers and students have not been helped since the inauguration of testing (p. 65).

Furthermore, Au (2007), who conducted a metasynthesis of 49 qualitative studies addressing high-stakes testing, concludes:

> The tests have the predominant effect of narrowing curricular content to those subjects included in the tests, resulting in the increased fragmentation of knowledge forms into bits and pieces learned for the sake of the tests themselves, and compelling teachers to use more lecture-based, teacher-centered pedagogies (p. 264).

Considering these statements, it is not very surprising that the achievement gap continues to widen. "Across this nation teachers have been mandated to use scripted programs (Allington, 2002; Altwerger, 2005; Shelton, 2005; Shannon, 2007; Meyer, 2010) and to deliver instruction that prohibits students from contributing their world knowledge" (Shelton, 2010 as cited in Shelton & Altwerger, 2015). Common Core and NGSS were supposed to help close the achievement gap by promoting equity (National Governers Association for Best Practices, 2010), but what students need to succeed are strategies to bridge the gap and FofK to help them identify with the content—not high-stakes assessments.

Throughout this study, FofK has been a key concept. FofK creates a two-way bridge that allows information to flow from the classroom to the students and from the students' out-of-school life to the classroom. The sharing of FofK, whether it be the teachers' stories or the students', creates a bond that is essential to building a learning community. It also gives a point of reference for immigrant students, or others who have recently relocated, to help them understand the culture of their new community. Using FofK to teach science can help close the achievement gap because it allows for all students' identities to be connected to the course content, not just the students whose social capital gives them access to the science-understanding community. The jumping through hoops concept of education must be done away with in order that teachers can have the time they need to insure that all students, not just the privileged, are able to identify with the science that is necessary for them to navigate society as adults.

Professional Development for Funds of Knowledge Isn't a Recipe

It is important to note that the results in this study can't be achieved by simply providing FofK professional development to teachers. Before Dana completed any FofK professional development, she had already established an environment conducive to building a learning community and incorporating students FofK. Teachers who are likely to be successful implementing a SCFofK approach will have already demonstrated the ability to create an engaging academic classroom and a positive emotional climate.

Future Research

Developing from this research, there are three major themes for future research that I believe would greatly advance secondary-science education, especially where student populations are diverse. Below I discuss these three themes: 1) building on students' FofK knowledge, 2) building on learning community knowledge, and 3) building on the power of stories and games in greater detail.

Building on Students' Funds of Knowledge

Although FofK has been studied for more than 25 years, it has only recently been adapted for use with diverse student populations. This is the first study that investigates a FofK approach in a diverse high-school chemistry course. Since this is the first study of this type, there is much more research to be done. Below are recommendations for further research in diverse high-school chemistry courses.

Chemistry Topics that Could Incorporate FofK.

During this research study, Dana developed FofK activities/units for three topics: alloys, molar mass, and nomenclature. There are certainly other chemistry topics which could be connected with students' FofK. Chemistry educators could benefit from an extended body of knowledge on using FofK in high-school chemistry classrooms in order to determine whether to use the approach with their students. This knowledge could also help teachers to determine which units they would like to implement a FofK approach. After reading the research, educators may decide to develop activities/units of their own. Chemistry education would greatly benefit from teachers who develop their own activities/units and implement them as part of an action research project.

FofK to FofK Collaborations between Students.

During the unit on alloys, several students related chemistry content to the chemical makeup of their musical instruments. A discussion about the different sounds produced, based on the alloys contained in the guitar rims, occurred naturally. I had anticipated that students' would be very engaged when they managed to connect chemistry content to a hobby that was so important to them. What had not occurred to me was that many students' would find that they had connections to each other in their out-of-school lives. Whether the hobby was musical instruments, die-cast toys, cooking, or technology, students who normally did not speak to one another in class found that they had shared interests. It would be interesting to research ways in which students, based on their out-of-school interests, can build collaborations that further deepen their learning experience and further build the strength of the learning community.

FofK with Other Student Populations.

Although it was not part of this study, Dana tried many of the FofK activities with her students in her honors class. She reported that she felt they benefitted from the activities as well. There is no reason that FofK approaches need to be limited to students who have been marginalized. Further research that explores using FofK with other student populations, including honors courses, AP courses, and regular chemistry courses, would be of value to determine how other populations may benefit.

Using FofK at the Beginning of the Course.

Because this study was designed to observe the class for several weeks before introducing FofK concepts, there was no FofK implementation at the beginning of the course. This, however, is when FofK can be extremely valuable in helping the teacher to learn about her/his students' knowledge and interests outside of school. Research that begins with a summer session of teacher professional development to learn about using a FofK approach would enable teachers to begin the school year using FofK. Not only would this help teachers to learn about their students earlier in the school year, it could also allow more time to build a stronger learning community.

Building on Learning Community Knowledge

In an age of high-stakes testing, it is easy to think of measurable course outcomes as being the only way to determine whether or not a course was successful. However, a positive change in students' perceptions of themselves and of their classmates can be life-changing and, perhaps, even more powerful than the "measurable learning" that takes place.

What Are Students' Perceptions of Science?

Marginalized students enter chemistry with a perception of science that may not be favorable. Research that compares students' perceptions of science before and after taking a FofK-based chemistry class could give insight into how students' identities can change after completing the course. A comparative study with a non-FofK-based chemistry classroom would help to determine whether any positive change in student identity is attributable to being taught using a FofK and building a learning community.

How Do Immigrant Students Perceive Themselves?

Immigrant students often enter high-school science classes with difficulty relating to American ways of perceiving the sciences (Edmonds 2009, Schiller 2007, Lee 2005, Lemke 2001). However, shared stories, using a FofK approach, and being part of a learning community may help these students to situate themselves in their new environment. Studies that focus on immigrant self-perceptions before and after taking this type of science course could help build our understanding of how to close the achievement gap. In fact, it may help to determine whether the so-called achievement gap is actually more of an opportunity gap on the part of our education system than a problem with students' ability to achieve.

Students' Perceptions of One Another.

Another benefit of building a learning community may be the respect that students gain for one another. As Isaac, a student with an IEP, shared his depth of knowledge about the die-cast process, I couldn't help but wonder how other students' perceptions of him were changing. Research that examines any differences in students' perceptions for one another could be valuable to gaining insight into ways in which teachers can better harness the collaborative potential of their learning communities. This knowledge could also build on the knowledge regarding the ways in which all students benefit from inclusion programs.

Building on the Power of Games and Stories

The use of student-led games and personal science-related stories were present, and appeared to be powerful, in Dana's class. Although it is possible to have a FofK approach class without these attributes, I believe that these contributed greatly to the community building that took place in Dana's class.

Student-led Games' Affect on Student Voice in the Classroom.

It was notable that some students who remained relatively silent during class discussions were very verbally active during the student-led game that Dana facilitated. More knowledge about the long-term classroom effects these types of games have on students' voice would help to inform educators about the validity of using class time to play games. Certainly, if students are better able to participate in class discussions after having participated in student-led games, it would be beneficial to allot some class time to these types of games.

Teachers' Personal Stories.

I was surprised by the power of the personal stories Dana shared with her students. As I thought about each student and how s/he might relate to the stories, it occurred to me how important it is to have further research on this topic. Western science has had the tradition of separating our identities from the sciences, but further research on the powerful impact of sharing personal science-related stories may help lead educators to question the validity of teaching science in an impersonalized manner.

Conclusion

In this chapter I have discussed several implications that have stemmed from this dissertation research. I have also discussed the need for future research regarding the building of knowledge on students' FofK as well as advancing knowledge on the use of learning communities in high-school science classrooms. Finally, the power of stories and games and the need to further develop knowledge regarding their effectiveness in secondary science education. Indeed, further research on this, along with other FofK research on the sciences, may lead to science education reform that could greatly benefit our changing and much more diverse student population.

Appendices

Appendix A: Classroom Discourse Transcript

Key

=	overlapping speech
?	rising intonation
Capitalized characters	emphasis
,	pause

LEAP Transcription 3/29/07

Lori (author): So, what are some things that you know that people do to take care of the water in your native countries--like the rivers and the lakes.

Arun: Umm, actually in India there are some lakes and rivers that are considered very divine=

Lori: =The lakes are very divine?

Arun: =There are some considered very divine like there are any animals that die near the rivers they take it out since lions and tigers they kill many animal and so they don't want those animals near water, so they take them out and you know there are fishes which kill em other fishes?=

Lori: =Uh huh.=

Arun: =They take even those fishes out.

Lori: Really?

Arun: Yeah. And even the they want to preserve the water when the fish come down=

Lori: So, they want to preserve the river because the water is divine?

Arun: Yeah.

Lori: You know what makes the water divine?

Arun: Um, it's it's just our culture, actually. Like in *Bible* they have like in *Bible* they have stories about how how God came and and you know what I mean?

Lori: Yeah.

Arun: Like in India there is a book there also that tells about how the waters came to the land=

Lori: =Yes.

Arun: and God sent them.

Lori: What's the book?=

Arun: =Huh?

Lori: What is the book?
Arun: It's called the *Rig al Veda*.

Lori: Okay.

Arun: Yeah.

Lori: And is that something that's very common that the people read and they know about?

Arun: Well, ah no they don't read, but it's a good book actually.

Lori: Do you know any stories about the water in the *Rig Veda*?

Arun: About right (inaudible) I'm not sure. It's just that God has created water land and in one of the stories God considered himself. Um, the best, the best liquid in the world is water.

Lori: That's that's interesting. That's in the *Bible* too. Did you know it's the, those of you that are familiar with the *Bible* it talks about the water being holy and that um. You know Jesus and a lot of other people were baptized in the Jordan river, right? They were baptized in water. Do you know from your other countries are there other waters that are holy?

Thomas: Is that, in India, like a river that wash away your sins?

Arun: Huh?

Thomas: Is there like a river that wash away all your sins? Cause I seen like a movie there's a river that wash away all your sins.

Arun: Yeah, well yeah that one one river. Like I. That's one river that the water will vanish.

Lorena: There's a river (inaudible)

Lori: Oh really? Do you know where that is?

Lorena: Uh, I'm not su-re=

Lori: But there are beliefs that are associated with that water?

Lorena: well, yeah uh people they they go there. They say the water helps them, but they say that that but you get in and it burn you a little bit.

Lori: Oh okay, so it's a hot spring.

Eddie: (inaudible) in Liberia like like in the country right? =

Lori: Uhuh.

Eddie: Yeah. they pick up that part here (points to the Atlantic shore of Liberia), right?

Lori: Do you know why they do that?

Eddie: Yeah cuz they're trying to keep it clean, right?

Malene: Yeah they do that in my country too.

Lori: Oh that's very nice.

Lori: Do you know um in Liberia are there um some beliefs some religious beliefs er just beliefs that people have about the water?

Eddie: Um it's the same thing in the *Bible* they say that yeah the water divine.

Lori: Is the water, then holy?

Eddie: Yeah.

Lori: So then what about in um Mexico. Do we know are there beliefs other than the hot springs are there beliefs about the water being special.

Lorena: Not really.

Arun: In India there is a hot spring water and it's in a part of the hill where the hill is about um three thousand feet above the sea level and that cold temperature hot waters are there=

Lori: uhuh.

Arun: yeah. uhuh, it's very col. Very ColD.

Lori: Well that's pretty amazing.

Arun: Uh huh, yes. It's actually one of the best wonders of the world.

Lori: Oh really. Have you been there?

Arun: Yeah, it's very good and it's very cold.

Lori: It's very cold on top of the mountain, but the water is very hot?=

Arun: =Uhuh=

Lori: That's very neat.

Eddie: Is there (inaudible)

Arun: Huh?

Eddie: I said is there a volcano=

Arun: No.

Lori: (To a student who just arrived) Come on in and sit down. We are talking about the water and people's beliefs about the water.

Thomas: …Bengal tigers.
Arun: Yeah, we have them.
Lori: You have what? Bengal Tigers.
Thomas: Yeah, Bengal Tigers.

Lori: So, Jose and Lucero do you know anything about the Popol Vuh?

Julio: The Popol who?

Lorena: Huh?

Lori: The Popol Vuh?

Julio: No.

Lorena: Ut uh.

Lori: It's an ancient text that was maybe written by ancient ancestors of yours.

David: Just like for me myself. I think I think that Americans Americans are just like out of this world right now cuz it's just crazy people putting trash like in the ocean and stuff. For me it's just like horrible for me cuz everytime I drink the water I think about the trash buildup and stuff that might be comin out the faucet=

Thomas: Really?

David: Like one time I was drinkin the water this plastic just came out the faucet and it almost made me choke to death.

Malene: You lie!

Laughing.

Malene: He's lying.

(We digress.) 10 minutes later:

Lori: Arun, you mentioned last week about a river that flows from the feet of God. Do you know any more about that?

Arun: Yeah that's right. The water comes from the feet of God. Actually, there some of the saints their um. I don't know in Christian how to say saints. In India and they live well (inaudible 24:00). Then the river. River has a god actually and then the goddess actually and that goddess um they did saying some, because they have some association with god because they say some prayers like god they pray so that they have more power. So, they not like the river. So the river ran from outside the country it it just ran and ran and ran and it come god and god save the river and again the river came to India. And the river is there again.

Lori: Oh, what what river?

Arun: It's called the Ganges.

Lori: Oh the Ganges!

Arun: Uhuh.

Misty: I just was reading about the Ganges and every year they say that the people have a pilgrimage there..

Arun: Yeah that's right.

Appendix B: Collaboration and Professional Development Schedule

Fall 11

Date	Collaboration	Readings	Assignments
Pre-Observation	Formal Interview		
Pre-PD Week 1: Sept 12	Informal Interview		
Pre-PD Week 2: Sept 19	Informal Interview		
Pre-PD Week 3: Sept 26	Informal Interview		
Pre-PD Week 4: Oct 3	Informal Interview		
Pre-PD Week 5: Oct 10	Informal Interview		
Pre-PD Week 6: Oct 17	Informal Interview	.	
Week 7: Oct 24	Participant Observation: Learn about culturally-responsive aspects of the school Discuss Reading	Rosebery, A. S. & Warren, B. (2008). *Teaching science to English language learners: Building on students' strengths*. NSTA Press. Pages 151-161	

Class	Participant Observation:		

Wee k 8: Oct 31	Participant Observation: Discuss Reading	Lee, O., & Luykx, A (2006). *Science education and student diversity: Synthesis and research agenda.* Cambridge: Cambridge University Press. Pages 72-91	
Wee k 9: Nov 7	Participant Observation: Discuss Reading Begin to compile students' known (FofK)	Gonzalez, N. (2005). Beyond Culture: The Hybridity of FofK. *FofK*. Lawrence Erlbaum Associates Publishers: Mahwah, New Jersey. Pages 29-46.	
Wee k 10: Nov 14	Participant Observation: Discuss Reading Continue to Compile students' known FofK	Edmonds, L. (2009). Challenges and solutions for ELLs: Teaching strategies for English language learners' success in science. *The Science Teacher*.	
Wee k 11: Nov 21	Participant Observation: Discuss Reading Introduction to Teaching with FofK Continue to compile students' known FofK	Valdez, G. (1996). Con Respeto: Bridging the Distance Between Culturally Diverse Families and Schools: An Ethnographic Portrait	
Wee k 12: Nov 28	Participant Observation: Discuss Reading FofK Approach Finish compiling students' known FofK	Hughes, M & Greenhough, P. (2006). Boxes, bags and videotape: enhancing home-school communication through knowledge exchange activities. Routledge.	
Wee k 13: Dec 5	Participant Observation: Discuss reading Identify where F of K may be used in your chemistry class		

15: Dec 19	FofK Review all aspects of the FofK Unit Plan. The unit will be observed as it is taught to the students taking Ms. [name] Chemistry Class		
Class 16: Jan 3	Participant Observation: FofK Unit being taught this week.		
Class 17: Jan 13	Participant Observation: FofK Unit Plan Reflection. We will reflect on the strengths and challenges of the FofK Unit Plan that was taught and discuss changes that would be made for using this approach to teach chemistry in the future.		
Post-PD Week 18: Jan 25	informal Interview		FofK Unit Plan Revisions
Post-PD Week 19: Feb 1	Formal Interview		

Appendix C: Pre-Observation Interview

1. I'd like to start by talking about [name] High School. It's a very ethnically-, racially-, and socioeconomically-diverse campus. Generally, the students seem to value this diversity.
    - Do you have any insight as to why they have this positive attitude? What can you tell me about any school- or district-wide efforts to encourage students to value diversity?
    - One element that is unique about [name] is that it is located on a military base. Can you tell me what the approximate percentage is of students who have a parent who is based at [name]?
    - Please tell me about the ethnic and racial diversity in your classroom.
2. This next set of questions deals with the diversity in your classroom. In your opinion, in what ways does having a class that is ethnically and racially diverse benefit classroom learning?
    - Are there any ways in which having a class that is ethnically and racially diverse create challenges in the classroom?
    - What strategies and techniques do you use to help students identify with the chemistry objectives being taught in class?
    - Are there any additional strategies or techniques that you use when you have students who are English language learners (ELLS)?
    - Are there and additional strategies or techniques that you use to help engage students who come from a culture that is different from your own?
    - Are there any strategies or techniques that you use to help engage students who come from a culture that is the same as or similar to your own?
    - Are there any other measures you take in order to create an equitable classroom?
    - Your co-taught class has a special education teacher? Paraprofessional? Please tell me about her/his role in the class? Do they actually co-teach part of the class or do they interact primarily with the students who have IEPs? Is the co-teacher responsible for classroom discipline?

3. Now I'd like to talk about you and your identity concerning science. Is it okay if we talk about the childhood and adolescent experiences you had with science?

    - Please tell me about your earliest recollection of science.
    - What other ways did you interact with science as you were growing up?
    - Did you have any science role models (scientist or science teacher) growing up? Do you have other family members who are in the sciences?
    - What made you want to become a science teacher?
    - What can you tell me about how your culture and race impact you as a chemistry teacher?
    - Please tell me about your teaching philosophy.
    - What racial or ethnic groups do you feel you are most prepared to teach? Why?
    - What racial or ethnic groups do you feel you are least prepared to teach? Why?
    - What knowledge or skills do you hope to gain from our collaborative research project?

Appendix D: Post-Professional Development Interview

1. The first weeks of this research project focused on my documenting the strategies and techniques that you were already using to engage students from diverse backgrounds. You have had the chance to look at what was written. Would you please tell me your thoughts about that documentation? I would like to know whether I captured what you were doing accurately and whether there is anything you would add or change about what I wrote.

2. What additional strategies or techniques do you use that perhaps I didn't observe?

3. During this research project we also did some professional development that focused on teaching classes that have students who come from diverse backgrounds. Would you please tell me about your thoughts and feelings about the professional development you received? Please feel free to share anything you like. The purpose of my asking this question is so that improvements can be made for teachers who receive professional development in the future.

4. Would you please tell me which part or parts of the professional development you found to be most helpful? Why?

5. Which part or parts of the professional development did you find least helpful? Why?

6. Let's talk about the FofK Unit that you developed. What are your thoughts and feelings about using a student-centered FofK approach?

7. What do you find are the strengths of using this approach?

8. What are the difficulties or weaknesses of this approach?

9. As you know, the purpose of using FofK is to help students identify with the content in order that they will be engaged. How do you feel this played out in the chemistry unit that you taught?

10. In what ways do you think the textbook used for this class helps or hinders your efforts to engage students?

Appendix E: Institutional Review Board Approval

UMBC

AN HONORS UNIVERSITY IN MARYLAND

Office for Research Protections and Compliance
University of Maryland, Baltimore County
1000 Hilltop Circle
Baltimore, MD 21250

PHONE: 410-455-2737
FAX: 410-455-3868
EMAIL: compliance@umbc.edu

Date: August 24, 2011

To: Lori Edmonds
Jonathan Singer

Re: Exemption Certificate
Protocol # : **Y12JS24018**

The Institutional Review Board has reviewed your protocol entitled **Teaching Diverse Students in a Secondary Chemistry Classroom** and has approved the application for certification as it met the criteria under **[category [[(§46.101(b)(1)]** for exemption from further IRB review. The date of approval is August 22, 2011.

Annual review is not required for this protocol since it was determined to be exempt. However, any changes to the research design or procedures that could introduce new or increased risks to human subjects must be submitted ***in writing*** for review by the IRB before the changes are incorporated to insure they do not change the exempt status of the protocol. All correspondence and materials used in this protocol must reference the above IRB number.

Exempt review approved by:

Susan Sonnenschein, Ph.D.
IRB Chair

Bibliography

Amanti, C. (2005). Beyond a beads and feather approach. In N. Gonzalez, L. Moll, & C. Amanti. *FofK: Theorizing practices in households, communities, and classrooms* (131-141). Mahwah, NJ: Erlbaum.

Au, W. (2007). High-Stakes Testing and Curricular Control: A Qualitative Metasynthesis, *Educational Researcher*. 36:5.

Barthes, R. 1977. Introduction to the structural analysis of narratives. In *Image-music-text*, trans. S. Heath, 79–124. New York: Fontana.

Barton, A. C. & Tan, E. (2008). FofK and discourses and hybrid space. *Journal of Research in Science Teaching*. Hoboken, NJ: Wiley.

Bellon, J., Bellon, E. & Blank, M.A. (1992). *Teaching from a research knowledge base: A development and renewal process*. New York: Macmillan.

Bettie, J. (2003). *Women without class: Girls, race, and identity*. Berkeley: University of California Press

Bielaczyc, K. & Collins A. (1999). Learning communities in classrooms: Advancing knowledge for a Lifetime. *NASSP Bulletin*. 83(604): 4-10.

Bilash, O. (2009). Best of Bilash: Improving second language education. Retrieved from http://www.educ.ualberta.ca/staff/olenka.bilash/best%20of%20bilash/gestures%20and%20visuals.html

Bourdieu, P. (1977). Cultural reproduction and social reproduction in Jerome Karabel and A. H. Halsey, eds., *Power and Ideology in Education*. New York: Oxford University Press.

Brewster, Ann B., & Gary L. Bowen. (2004). Teacher support and the school engagement of latino middle and high school students at the risk of school failure. *Child and Adolescent Social Work Journal,* 21(1), 47-67.

Calloway, L., & Knapp, C. (1996) *Using grounded theory to interpret interviews*. Retrieved from http://csis.pace.edu/~knapp/AIS95.htm.

Charmaz, K. (2005). Grounded theory in the 21st century: Applications for advancing social justice studies. In N. K. Denzin & Y. S. Lincoln (Eds.), *The sage handbook of qualitative research* (3rd ed.). (507-536). Thousand Oaks, CA: Sage.

Chèche Konnen Center (2010). Chèche Konnen Center: Search for Knowledge. Retrieved from http://chechekonnen.terc.edu/

Cheryan, S. & Bodenhausen, G. V. (2000). When Positive Stereotypes Threaten Intellectual Performance: The Psucholgical Hazards of "Model Minority" Status. *Psychological Science*. Vol. 11, No 5, Sept.

Cobern, W., Gibson, A., and Underwood, S. (1995). Paper presentation from Strand Two of the 1995 annual meeting of the National Association for Research in Science Teaching. *Everyday thoughts about nature: An interpretive study of 16 ninth graders' conceptualizations of nature.*

Cobern, William W., & Loving, C. (2001). Defining "science" in a multicultural world: Implications for science education. *Science Education* 85, 50-67.

Collins, R. & Pamela J. Cooper (2005). *The Power of Story: Teaching through Storytelling* (2nd ed.). Long Grove, Il: Waveland Press.

Crandall, J., (2009). UMBC STEP T Conference. *Stepping Up Teacher Leadership in Maryland*.

Cummins, J. (1979). Cognitive/academic language proficiency, linguistic interdependence, the optimum age question and some other matters. *Working papers on bilingualism.* 19, 121–129.

Cummins, J. (1981). The role of primary language development in promoting educational success for language minority students. In California State Department of Education (Ed.), *Schooling and Language Minority Students: A Theoretical Framework*. Los Angeles.

Cummins, J. (2010). Proceedings from *Imagining a Multicultural TESOL*. TESOL 44th Annual Convention Dream Day. Boston, MA.

Delpit, L. (2006). *Other people's children: Cultural conflict in the classroom*. New York: The New Press.

Denzin, N.K. & Lincoln, Y.S. (2005). Introduction: The discipline and practice of qualitative research. *The sage handbook of qualitative research* (3rd Ed.). Thousand Oaks, CA: Sage Publishers.

Department of Legislative Services (2008). *Maryland 2020: A State in Transition*. Retrieved from: dls.state.md.us/data/Maryland_2020_A_State_in_ Transition.pdf

Edmonds, L. M. (2008). Globalizing environmentalism: Immigrants in Maryland share their environmental knowledge and practices while learning English. *The international journal of diversity in organizations, communities & nations,* 8:5, 199-205.

Edmonds, L. M. (2009). Challenges and Solutions for ELLs. *The Science Teacher*, 76(3):30-33.

Elmesky, R., & Seiler, G. (2007). Movement expressiveness, solidarity and the (re)shaping of African American students' scientific identities. *Cultural Studies of Science Education*, 2(1), 1871-1510.

Emerson, R. M., Fretz, R. I. & Shaw, L. L. (1995). *Writing ethnographic fieldnotes*. Chicago: University of Chicago Press.

Enright, S. D. (1992). Supporting Children's English Language Development. *Focus on the Learner*. Upper Saddle River, NJ: Prentice Hall.

Fontana, A. & Frey, J. H. (2005). The interview: From neutral stance to political involvement. In N. K. Denzin & Y. S. Lincoln (Eds.), *The sage handbook of qualitative research* (3rd ed.). (695-727). Thousand Oaks, CA: Sage.

Gay, G. (2000). *Culturally responsive teaching: Theory, research, & practice*. New York: Teachers College Press.

Geertz, C. (1973). *The interpretation of cultures: Selected essays*. New York: Basic Books.

Goldstein, Mark (2006). *Maryland's Changing Demographics*. Leadership Challenge XV, Maryland Department of Planning.

Goldstein, Mark. (2012). Already a Majority-Minority Maryland (below 40). The D4TA M1NE: A Blog by the Maryland State Data Center. Retrieved 2/23/2016 from https://md datamine.wordpress.com/2012/08/08/already-a-majority-minority-maryland-below-40/

Gonzalez, N. & Moll, L. (2002) Cruzando el punte: Building bridges to FofK. *Education Policy*, 16, 623-641.

Gonzalez, N., Moll L., & Amanti, C. (2005). *FofK: Theorizing practices in households, communities, and classrooms*. Erlbaum: Mahwah, NJ.

Gottlieb, A. (2006). Ethnography: Theory and Methods. *A Handbook for Social Science Field Research: Essays & Bibliographic Sources on Research Design and Methods*. In Perecman, E & S.R. Curran (Eds.). Sage, Thousand Oaks, CA. 47.

Greenwood, D.J. & Levin, M. (2005). *Reform of the Social Sciences and of Universities through Action Research. The Sage Handbook of Qualitative Research, 3rd Edition*. Sage Publishers, Thousand Oaks, CA.

Hall, J. K. (2002). *Methods for Teaching Foreign Languages: Creating A Community of Learners in the Classroom*. Pearson. Upper Saddle River, NJ.

Hanson, S. L. (2009). *Swimming against the tide: African American girls and science education*. Philadelphia: Temple University Press.

Hattie J. & Timperley H. (2007). The Power of Feedback. *Review of Educational Research* 77(1):81-112.

Hughes, M & Greenhough, P. (2006). Boxes, bags and videotape: enhancing home school communication through knowledge exchange activities. *Educational Review*, 58:4. New York: Rouledge.

Jackson, C. (2011). *Your Voice. How Humor Affects Learning* (television interview). Ontario Public Educational Media Association.

John-Steiner, V., & Mahn, H. (1996). Sociocultural approaches to learning and development: A Vygotskian framework. *Educational psychologist*, 3(3/4), 191-206.

Kincheloe, J. L., & McLaren, P. (2005). Rethinking critical theory and qualitative research in *The sage handbook of qualitative research 3rd edition*. Thousand Oaks, CA: Sage Publications.

Latshaw, G. (2011). Diversity grows with population in Maryland. USA Today. Retrieved from http://www.usatoday.com/cleanprint /?unique=1305826717387.

Lave, J., & Wenger, E. (1991). *Situated learning: Legitimate peripheral participation*. Cambridge: Cambrige University Press.

Lemke, J.L. (2001). Articulating communities: Sociocultural perspec- tives on science education. *Journal of Research in Science Teaching,* 38(3): 296–316.

Lee, O. (1997). Diversity and equity for Asian American students in science education. *Science Education,* 81(1), 107-122.

Lee, O. (2005) Diversity and Equity for Asian American Students in Science Education. *Science Education*, 81(1): 107-122.

Lee, O. (2005). Science education with English language learners: Synthesis and research agenda. *Review of Educational Research,* 75(4): 491–530.

Lee, O., & Luykx, A (2006). *Science education and student diversity: Synthesis and research agenda.* Cambridge: Cambridge University Press.

Lee, O., & Buxton, C. A. (2010). *Diversity and equity in science education: Research, policy, and practice*. New York: Teachers College Press.

Lefevre, K. B. (1987). *Invention as a social act*. Carbondale and Edwardsville, Il: Southern Illinois University Press.

Lemke, J. L. (1990). *Talking science: Language, learning, and values*. Westport, CT: Ablex Publishing.

Lewis, C., Enciso, P., & Moje, E.B. (2007). *Reframing sociocultural research on literacy: Identity, agency, and power*. Mahwah, NJ: Lawrence Erlbaum Associates.

MacLeod, J. (2008). *Ain't no makin' it: Aspirations & attainment in a low-income neighborhood*. Boulder, CO: Westview Press.

Maryland Department of Planning. Census 2010 Population Highlights. Retrieved from http://planning.maryland.gov/mdsc/census/cen2010/ PL94-174/Census%202010%20Population%20Highlights.pdf

Maryland Report Card (2010). Adequate Yearly Progress: Anne Arundel County. Retrieved from www.mdreportcard.org.

Moll, L. C. & Greenberg, J. B. (1990). Creating zones of possibilities: Combining social contexts for instruction in *Vygotsky and education: Instructional implications and applications of sociohistorical psychology*. Moll (Ed.). Cambridge: New York.

Moll, L. C., Amanti, C., Nell, D. & Gonzalez, N. (1992). FofK for teaching: Using a qualitative approach to connect homes to classrooms, *Theory Into Practice*, 31.

National Center for Education Statistics (2004). School and Staffing Survey (SASS). Retrieved from http://nces.ed.gov/surveys/SASS/tables/state_2004 _18.asp.

National Center for Educational Statistics (2009). Characteristics of public, private, and bureau of Indian education elementary and secondary school teachers in the United States: *Results from the 2007-08 schools and staffing survey*. Retrieved from http://nces.ed.gov/pubs2009?2009324/tables/sass0708_2009324.

National Center for Educational Statistics (2011). Public elementary and secondary school student enrollment and staff counts from the common core data: School year 2009-10. Retrieved from http://nces.ed.gov/pubs2001/snf2009 10/tables/table _02.asp.

National Governers Association for Best Practices (2010). *Common Core State Standards*. Washington, D.C. Retrieved from http://www.corestandards.org/.

National Science Education Standards (1996). Retrieved from http://www.nap.edu/openbook.php?record_id=4962&page=50.

U.S. Department of Education National Center for Education Statistics (2005). Common Core Data. Retrieved from http://zipskinny.com/index.php?zip=20755& pagetype=schools.

Schiller, L. 2007. *Science apprenticeship: Reading, writing, and talk- ing our way into scientific literacy*. Presentation at the NSTA Conference on Science Education, Detroit.

Smith, F. (1998). *The Book of Learning and Forgetting*. Teachers College Press: New York: NY.

Ogbu, J. U. (1987). Variability in minority school performance: A problem in search of an explanation. *Anthropology and education quarterly* 18(4), 312-334.

Ogbu, J.U. (1992). Adaptation to minority status and impact on school success. *Theory into Practice*, 31, 287-95.

Ogbu, J. U. & Simons, H. D. (1998). Voluntary and involuntary minorities: A cultural-ecological theory of school performance with some implications for education. *Anthropology & Education Quarterly* 29(2), 155-188.

Orfield, Gary. (2004). Losing our Future: Minority Youth Left Out. *Dropouts in America: Confronting the Graduation Rate Crisis*. In Orfield, Gary (Ed.). Cambridge, Massachusetts. 131-155.

Orfield, Gary, & Chungmei Lee, C. (2006). *Racial Transformation and the Changing Nature of Segregation*. Report for the Civil Rights Project, Harvard University.

Penfield, R. D., & Lee, O. (2010). Test-based accountability: Potential benefits and pitfalls of science assessment with student diversity. *Journal of Research in Science Education*, 47 (1), 6-24.

Pew Research Center (2008). *Country of Origin Profiles*. Retrieved from http:/pewhispanic.org/data/origins/.

Rosebery, A. S. & Warren, B. (2008). *Teaching science to English language learners: Building on students' strengths*. NSTA Press.

Rosenthal, J. W. (1996) in Hanson, S. L. (2009). *Swimming against the tide: African American girls and science education*. Philadelphia: Temple University Press.

Said, E. W. (1993). *Culture and Imperialism*. New York: First Vintage Books.

Schensul, S., Schensel, J., & LeCompte, M. (1999). *Essential Ethnographic Methods: Observations, Interviews, and Questionnaires*. Walnut Creek, CA: Alta Mira Press.

Singer, J., Marx, R.W., Krajcik, J., & Chamber, J. C. (2000). Constructing extended inquiry projects: Curriculum materials for science education reform. *Educational Psychologist*, 35(3), 165-178.

Smith, P. S. (2002). *2000 National Survey of Science and Mathematics Education: Status of School Chemistry Teaching*. Horizon Research, Inc. Chapel Hill, NC.

Snow, C. P. (1960). *The two cultures*. Cambridge: University Press.

Stake, R. E. (2005). Qualitative Case Studies in *The sage handbook of qualitative research 3rd edition*. Thousand Oaks, CA: Sage Publications.

Strauss, A., & Corbin, J. (1990). *Basics of qualitative research: grounded theory procedures and techniques.* Thousand Oaks, CA: Sage Publications.

Thomas, & Collier (2002). *A national study of school effectiveness for language minority students' long-term academic achievement*. Santa Cruz, CA: Center for Research on Education, Diversity & Excellence, University of California.

Unknown (2010). America's Best High Schools: The List. *Newsweek*. Retrieved from http://www.newsweek.com/feature/2010/americas-best -high-schools/profile.html?key=yfbEqVb7Btp3luF88DH5QfKb2Dw&state=MD&year=2010&id=2280&detailsKey=N28nvfpWt2-SGAP9X-BN5pk52fg

Valdez, G. (1996). *Con Respeto: Bridging the Distance Between Culturally Diverse Families and Schools: An Ethnographic Portrait.* New York: Teachers College Press.

Valenzuela, A. (1999). *Subtractive schooling: U.S.-Mexican youth and the politics of caring*. New York: University of New York Press.

Velez-Ibanez, C. G., (1996). *Border visions: Mexican cultures of the Southwest United States*. Tucson: The University of Arizona Press.

Velez-Ibanez, C. G., & Greenberg, J. B. (1992). Schooling processes among U.S. Mexicans, Puerto Ricans, and Cubans: A comparative, distributive, and case study approach. In Thomas Weaver (Ed.) *Hispanics in the United States*. Houston: Arte Publico Press.

Vygotsky, L. S. (1978). *Mind in society: The development of higher psychological processes*. M. Cole, V. John-Steiner, S. Scribner, & E. Souberman (Eds.). Cambridge, MA: Harvard University Press.

Wenger, E. (1998) *Communities of practice: Learning, meaning, and identity.* NY: Cambridge University Press.

Wertsch, J. V., (1990). The voice of rationality in a sociocultural approach to mind in *Vygotsky and education: Instructional implications and applications of sociohistorical psychology*. L. C. Moll (Ed.). New York: Cambridge University Press.

Wilcox, S. (2008). *Ethnographic Research and the Problem of Validity*. Retrieved from http://dscience.com/wp-content/uploads/2014/09/DS-Ethnographic-Research.pdf