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## Transformative Multicultural Science Curriculum: A Case Study of Middle School Robotics

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TRANSFORMATIVE MULTICULTURAL SCIENCE CURRICULUM:  
A CASE STUDY OF MIDDLE SCHOOL ROBOTICS

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## THE GRADUATE COLLEGE

We recommend the dissertation prepared under our supervision by

**Mary Katheryn Grimes**

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**Transformative Multicultural Science Curriculum: A Case Study of  
Middle School Robotics**

be accepted in partial fulfillment of the requirements for the degree of

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**August 2012**

## ABSTRACT

### **Transformative Multicultural Science Curriculum: A Case Study of Middle School Robotics**

by

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Multicultural Science has been a topic of research and discourse over the past several years. However, most of the literature concerning this topic (or paradigm) has centered on programs in tribal or Indigenous schools. Under the framework of instructional congruence, this case study explored how elementary and middle school students in a culturally diverse charter school responded to a Multicultural Science program. Furthermore, this research sought to better understand the dynamics of teaching and learning strategies used within the paradigm of Multicultural Science. The school's Robotics class, a class typically stereotyped as fitting within the misconceptions associated with the Western Modern Science paradigm, was the center of this case study. A triangulation of data consisted of class observations throughout two semesters; pre and post student science attitude surveys; and interviews with individual students, Robotic student teams, the Robotics class instructor, and school administration.

Three themes emerged from the data that conceptualized the influence of a Multicultural Science curriculum with ethnically diverse students in a charter school's Robotics class. Results included the students' perceptions of a connection between science (i.e., Robotics) and their personal lives, a positive growth in the students' attitude

toward science (and engineering), and a sense of personal empowerment toward being successful in science. However, also evident in the findings were the students' stereotypical attitudes toward science (and scientists) and their lack of understanding of the Nature of Science.

Implications from this study include suggestions toward the development of Multicultural Science curricula in public schools. Modifications in university science methods courses to include the Multicultural Science paradigm are also suggested.

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## Dedication

I dedicate this work to my loved ones that have moved on to the next realm during the time I have been seeking this doctorate degree. Without their love and encouragement, I would have never begun or completed this journey.

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## CHAPTER 1

### INTRODUCTION

We have allowed our schools to remain in the past, while our children have been born in the future. The result is a mismatch of learner and educator. But it is not the children who are mismatched to the schools; the schools are mismatched to the children. Only by revising educational practice in light of how our culture has changed can we close this gap and reunite our schools with our children and the rest of our society. (Strommen & Lincoln, 1992, p. 475)

Over the past 50 years, the United States educational system has struggled with changes occurring in our society and the influences these changes have had on our schools. The above quote from Strommen and Lincoln, profound as it is, was written in 1992, yet it is still relevant for our educational dilemmas today, 20 years later.

At the forefront of our concerns is science education. According to the Trends in International Mathematics and Science Study (TIMSS) released in September 2008, only 15% of fourth graders and 10% of fifth graders reached the TIMSS advanced international benchmark in science, receiving a ranking of fourth and eleventh, respectively, out of 36 countries who participated in the evaluations (National Center for Educational Statistics, 2008). However, according to the 2009 Programme for International Student Assessment, the United States ranked 30<sup>th</sup> out of 63 participating countries in Student Science Proficiency with 15 year olds (OECD, 2010). Additionally, the National Science Foundation (NSF, 2008) reported that the percentage of United States high school graduates who completed advanced engineering and science technologies courses between 1990 and 2005 has only increased by a few points.

These numbers point to a decrease in the number of scientists to face future critical national and global scientific endeavors—such as environmental issues, alternative energy, space exploration, and medical research. Why are students becoming out of touch with science? This question has been researched and tested almost to exhaustion—with no clear answer, except for the one offered by Strommen and Lincoln (1992), quoted earlier. Are our schools operating with *outdated* philosophies? Are our students *connected* to the teaching strategies that are mandated in the classrooms? Do we need to examine our educational practices as they relate to the *cultures* within the classrooms? How can we provide *equality* for all cultures in our science classes?

Precollege and university personnel have been watching this decline in science education and careers, while desperately trying to find solutions. New “fix-all” programs have come and gone, papers have been presented at countless educational conventions, and even organizations have been formed to support the cultural diversity within the science classroom. Far too few positive results have surfaced. I am convinced that we are on a good path toward science education reform. However, reform, i.e., change, is akin to the proverbial sloth—moving so slowly that moss flourishes and weighs on its back. Resistance to change, accountability issues, political sidetracking, and especially accountability legislation are all part of the “moss” that weighs heavily on the back of science education reform. Strommen and Lincoln (1992) suggest that educational reform can only occur when the different cultures in our classrooms are acknowledged, appreciated, and addressed through a different approach—a multicultural curriculum. Thus, Multicultural Science has recently advanced to the forefront of the science educational reformation movement. In the next two sections, a brief history of our

country's science education and a snapshot of current views of science education will be addressed.

### **The Way We Were**

Eurocentric Science, also referred to as Western Modern Science (WMS), began in Greece and has been the “dominant power” of science for centuries. As Europeans came to this continent, their (self-imposed) superiority became the norm for education in the public schools. With respect to the historical origins of educational strategies used by science educators, which are probably the strategies most of us experienced, Michel Foucault, as cited by Hadi-Tabassum (2005), notes the following.

Institutions such as schools have perpetuated a structuralist epistemology that inhibits alternative ways of thinking by adhering to conformist forces that strain the sciences with prescriptive rules of formation or epistemes. These conformist forces support a strictly Western epistemology that has controlled scientific institutions from the classical age onward with its rule-base claim of infallible and absolute truths. (pp. 188-189)

William Doll (1993) proposes that the Western, modernist view of science education originated in this same perspective. Modernist views stems from the progressive Industrial Revolution during the 18<sup>th</sup> and 19<sup>th</sup> centuries, when the United States transformed from a lower level agricultural power to a leader in the world of industry. Doll further contends that control is the most important characteristic of the modernist's reign. It is this same characteristic that disallows modernism to relinquish its hold in education.



Therefore, since the science community is grounded in the traditions of Western science, it has its own ideas and misconceptions about what science education in schools should achieve.

Traditional scientists believe that science education should provide interested students with the background that they need to become successful scientists and should inform future taxpayers of the importance of science and technology in order to ensure continued funding for scientific research. (Cobern, 1996, p. 585)

Furthermore, Aikenhead (1996) states that many people do not believe that cultural “voices” are relevant to scientific issues. Hence, science is perceived to be “culture-free, gender-free, and ethnicity-free” (p. 224). Aikenhead, as well as others (Fixico, 2003; Luft, 1998; Snively & Corsiglia, 2001), contend that modern science is a sub-culture of the White-male Western culture, which compounds the premise that culture, gender, race, and/or class are extraneous in any true scientific endeavor.

Ogawa, as cited by Carter, Larke, Singleton-Taylor, and Santos (2005), proposes that Western science is not really accessible to most Westerners as well. “The science community is like a special kind of ‘club’ that has its own rules, and if you are not willing to play by those rules, you cannot become a member” (p. 6). The influence that Western Modern Science has had on our Nation (including our educational system) is to transform, control, and master nature while promoting individual success and competition (Hodson, 1993). Can our Nation continue to prosper in the global community with this stifling attitude toward science and the stereotypical constructs that it implies?

Russell Means, as cited by Fixico (2003) states, “In the linear, mathematical way of the Eurocentric male society that has long dominated America, one is expected to

know things, to believe things. Knowing and believing are all in your head—there is nothing in your heart” (p. 89). He continues with telling a story from his childhood. What would happen if the green things that grow were taken from the Earth, or the four-legged animals, or the winged creatures, or all the animals that crawl and swim and live within the earth were taken from the Earth? There would be no Earth. However, if all humans were taken from the Earth, the Earth would flourish. It is this holistic mind-set that diverse cultures can bring to the science classroom.

### **The Way We Are**

The demographics in our country are continuously changing. Persons of color now constitute approximately 36% of our country’s population (U.S. Census Bureau, 2010). It is predicted that by the year 2050, over half of the U.S. population will be people of color—primarily of Asian, Hispanic, and African American decent (U. S. Census Bureau, 2010). As expected, this cultural boom has directly affected the demographics in our Nation’s classrooms. The National Center for Education Statistics (NCES, 2011) predicted that by the year 2020, students of European decent [Caucasian] and students of color will each make up 50% of the Nation’s student population. In the Southwestern state of this study, the story has already moved beyond these forecasted numbers. The state’s Department of Education reports 41.7% of its total students are Caucasian, while 58.3% are students of color (State Education Department website, 2009). Furthermore, in the county of this research, 65.4% of the total students enrolled in its school district are students of color, and only 34.6% are Caucasian (anonymous Accountability Report, 2009). Do our schools acknowledge these children beyond the statistical numbers reported every year, or are our educational institutions (both pre-

college and university levels) still marching ahead, using the “tried and true” teaching strategies of years past?

Multicultural education has been a battle cry for decades now. Courses related to this discipline are required of most undergraduate and graduate teaching certification programs. However, years of single semester classes have, many times, simply educated preservice teachers on the atrocities that have been afflicted upon different cultures in our country. No one denies that this approach is a vital part of emphasizing the awareness, appreciation, and acceptance toward the various cultures represented within the classroom. However, these one semester classes have not been enough (Cobern, 1998; Eldering & Leseman, 1999; Gay, 2003; Gollnick & Chinn, 2002; Hines, 2005; Lee & Luykx, 2007; Rodriguiz & Kitchen, 2005).

To demonstrate this point, I recently attended a staff development meeting on multicultural education at a local elementary school. Many of the teachers were obviously disconnected from this topic, as I observed them talking to each other during the presentations, grading papers, and leaving the room for 10 or more minutes at a time. Later, one third grade teacher commented to a nearby colleague, “Why do we have to go through these meetings again? I’ve always treated all of my kids the same.” This young teacher had certainly reached the “tolerance” level in her multicultural education; however, with all of her good intentions, she unknowingly stated the real problem. She may be treating all of her students the same, but it is the way a Caucasian woman thinks and acts—not the way her students of diverse cultures may think and act.

Geneva Gay (2000) reflects on this type of scenario by stating the following.

The individuality of students is deeply entwined with their ethnic identity and cultural socialization. Teachers need to understand very thoroughly both the relationships and the distinctions between these to avoid compromising the very thing that they are most concerned about—that is, students’ individuality.

Inability to make distinctions among ethnicity, culture, and individuality increases the risk that teachers will impose their notions on ethnically different students, insult their cultural heritages, or ignore them entirely in the instructional process. (Gay, 2000, p. 23)

In further evidence of teachers’ perceptions of Multicultural Science professional development (PD), Chval, Abell, Rareja, Musikul, and Ritzka (2008) found that teachers ranked the two lowest priorities in science PD as (a) involving girls or minorities in math/science and (b) designing instruction for ESL students in math/science. One may surmise from this report that teachers may not realize the critical need for addressing multicultural science, and they may not have the pedagogical tools to include this epistemology into their own teaching styles.

This point was also brought to the forefront by Howard (2006) in restating the old adage, “We can’t teach what we don’t know.” Many teachers, like the one mentioned earlier, have no understanding of what multiculturalism looks like in curriculum development, assignments, and attitudes in the classrooms. University courses and mandated professional development must include the multiple dimensions of a multicultural classroom environment, not just the idea of “treating” everyone the same (Howard, 2006).

## **Pulling Together the Past and Present**

The numbers of students pursuing advanced science classes and science careers are now stagnant, and in some cases falling (OECD, 2010). United States science test scores rank lower than those of many other countries; additionally, the U.S. is currently experiencing one of the largest influxes of immigration in history. Whereas classroom student populations in prior decades have been predominately Caucasian, most classrooms—at least in the district of this research—currently override these historical statistics and have a preponderance of students from numerous cultures. “The challenge for these students is to study a Western scientific way of knowing and at the same time respect and access the ideas, beliefs, and values of non-Western cultures” (Snively & Corsiglia, 2001, p.24). In order for these students to reach any kind of success in their science education, they must learn to negotiate the two cultures – i.e., their home culture and the specific culture of their science classroom. This “border crossing” (Giroux, 1992) for students is also necessary for teachers and administrators in building and practicing teaching strategies that are adapted to fit the cultural essence the students bring with them to school. Unfortunately, that is not practiced in most classrooms nor expected by most school administrators.

In the following section, a discussion of Multicultural Science will be presented. Characteristics of a multicultural curriculum, its instructional strategies, and how it contrasts to the misconceptions associated with Western Modern Science will be discussed.

## **What is Multicultural Science?**

When I asked this question to my elementary science methods preservice teachers, their suggestions for science lessons were to have students research/report scientists of color and make a presentation to the class; present a lesson to students about land formations and how they affect the economy of the cultures that live in that area, and to learn about the plants and animals that different cultures have used for survival. While these topics are appropriate when woven into science lessons that include a cultural component, they do not address the overall instructional strategies of the Multicultural Science paradigm.

Multicultural Science is not easily defined, such as a word explained in a dictionary. It involves a holistic way of thinking; a process of active learning; discourse among students, families, and communities; and relevant, student-centered curriculum (Cajete, 1999; Gaskell, 2003; Lee, 2003). Furthermore, Multicultural Science demands “instructional congruence.” Luykx and Lee (2005) explored the concept of instructional congruence as it relates to student diversity with the demands of academic disciplines (e.g., science). Their definition states: “Instructionally congruent teaching requires that teachers have knowledge of both academic disciplines and student diversity...It is to guide teachers in recognizing students’ prior linguistic and cultural knowledge and the relation of this knowledge to scientific content and practice” (p. 426).

Other characteristics of Multicultural Science include the following.

- An inclusive approach—Emphasize to students that all cultures have worthy contributions to make to scientific discourse and exploration (Cajete, 1999; Gaskell, 2003; Lee, 2003).

- Uses of cultural languages—Students’ native languages bring science into their personal lives (Barba, 1998; Olneck, 2004; Rollnick, 1998).
- Visiting scientists—Men and women scientists of color are powerful role models for all students (Abdi, 1997; Hines, 2005; Zacks, 1999).
- Learning style—Knowing the learning styles and cultural traditions of students informs students that the instructor cares about their education (Calabrese Barton, 2003; Hines, 2005; & Luykx, 2007).
- Constructivist approach—An active, hands-on atmosphere in learning scientific concepts is conducive to becoming a life-long learner. The student’s knowledge base and personal experiences become key factors in the learning of science (Cajete, 1999; Carter, et al., 2005; Cobern, 1996; Doll, 1993; Eldering & Leseman, 1999; Gay, 2000, 2003; Lee & Luykx, 2007; Rodriguez & Kitchen, 2005).
- Student autonomy—The teacher is not the fountain of knowledge; students and teachers work together to construct knowledge (Atwater, 1995; Bryant, 1996; Doll, 1993). “Teachers would invite students into modes of dialogue as participants rather than pawns, as collaborative interlocutors instead of slates to be filled” (Gergen, 1991, p. 250).
- Connection—All science is connected to every concept in the universe. For example, life science—without its connection to physics, chemistry, earth science, math, literature, writing, history, anthropology, etc.—would be a very shallow discipline (Cajete, 1999). Capra, as cited by Cajete, describes these connections noting, “Natural systems everywhere ‘transact’ in mutualistic,

interrelationships at a huge variety of different levels. They are synergistic, which means that the whole of the system is always greater than the sum of its parts” (p. 158).

- Relevance—All science is relevant to the student, the family, the classroom, the school, the community, the world, and the universe (Aikenhead, 1996; Barba, 1998; Cajete, 1999; Fixico, 2003).
- Circles—Everything in our universe is governed by and rooted in circles. Within the circle of life, a continual effort for balance is the purpose for individuals and communities. The linear person may not realize the importance of this effort as Western cultured people are often consumed by work or thoughts of getting something done during the day. What Western society does not normally do is to put things in the larger perspective of life. Nor does the linear mind prioritize what is important to him or her as a person in relationship to family and community, thus placing personal needs first. (Fixico, 2003, p. 48)

This final point by Fixico (2003) brings to the forefront the difference between Western Modern Science and Multicultural science, especially as it is portrayed in conventional curricula. WMS is linear in nature, i.e., there is a beginning and an end to a concept (e.g., Earth Science vs. Life Science) as well as time (e.g., Math time vs. Reading time). WMS also allows the clock to dictate educational projects and discourse, e.g., “If you don’t finish this before lunch, it will be your homework.” In contrast, Cajete (1999) emphasizes the connection of all subjects, all things, and all people.



Doll (1993) defined this educational movement away from modernist practices as “transformative,” meaning that curriculum built on student-centered pedagogy has the ability to transform our schools from positivistic practices to those appropriate for a post-modernistic society. The infusion of a transformative, multicultural approach into a science curriculum that is fundamentally rooted in WMS, requires two major steps—the first of which is an in-depth awareness of the Nature of Science (NOS), described by Lederman (1992) as “the values and assumptions inherent in the development and interpretation of scientific knowledge” (p. 331). The second step is in understanding the characteristics of a transformative science curriculum under the overall umbrella of constructivism. The following section will discuss these points as they relate to the accomplishment of border crossing and instructional congruence. Border crossing not only involves teachers and administrators, but also the students, their families, and the communities of the culturally diverse school populations.

### **Bridging the Gap between Eurocentric (Western) Science and Multicultural Science**

**Transformative curriculum.** In the changing scenery of our society and, with it, the dawning of new educational thought, a transformative curriculum is essential (Doll, 1993; Hadi-Tabassum, 2008; Mertens, 2009). In defining this paradigm, Doll describes the “4 R’s”—richness, recursion, relation, and rigor—as a new direction, which is opposite from the traditional “3 R’s” of reading, writing, and arithmetic. Following is a brief description of Doll’s components of a transformative curriculum.

1. Richness – This term refers to the depth of the curriculum, “to its layers of meaning, to its multiple possibilities or interpretations” (Doll, 1993, p. 176). He contends that properly applied disequilibrium and lived experiences are

fundamental in developing richness in a curriculum. For example, while studying photosynthesis, students may be observing the embryonic plant inside a bean seed. When a student observes that a new leaf is present in the embryo, the teacher may say, “How could that be a leaf? Leaves are green. Any other observations?” This stirs an equilibrium shift, i.e., disequilibrium, so that the students may begin a conversation of disagreement, finally getting to the conceptual agreement that the observed object is indeed a cream-colored leaf because it has not grown yet. At this point, the teacher moves toward having students hypothesize what would cause the leaf to become green. Suggestions are put to the test, and experiences are formed.

2. Recursion – Doll (1993) is clear in his explanation that recursion and repetition are very different. Recursion refers to reflecting on our own thoughts and reasoning. In the above example, recursion occurs when the teacher acknowledges the student’s explanations and challenges all students to think through things further to develop a hypothesis based on their thinking.

Repetition, a strong element in the modernist mode, is designed to improve set performance. Its frame is closed. Recursion aims at developing competence—the ability to organize, combine, inquire, use something heuristically. Its frame is open. The functional difference between repetition and recursion lies in the role reflection plays in each. (Doll, 1993, p. 178)

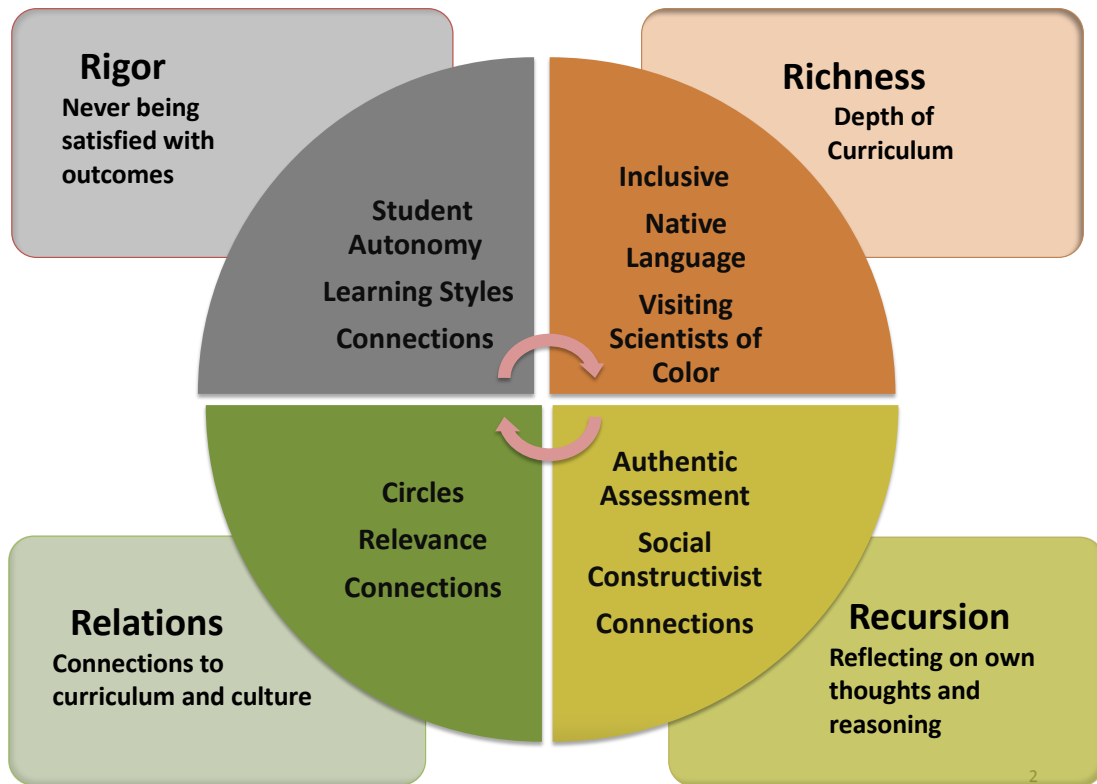
3. Relations – Doll (1993) contends that this component is critical in a transformative curriculum, and can be divided into two essential parts – the

connection of curriculum and the connection of culture. First of all, Doll emphasizes the development of pedagogical relations, i.e., how topics, curriculum, and language bridge to each other through recursion. “Curriculum in a [transformative] frame needs to be created (self-organized) by the classroom community, not by textbook authors” (p. 180). Secondly, Doll’s component of relations also pertains to the understanding of local culture as it is connected to world cultures within the curriculum’s objectives.

As teachers we cannot, do not, transmit information directly; rather, we perform the teaching act when we help others negotiate passages between their constructs and ours, between ours and others. This is why Dewey says teaching is an interactive process with learning a by-product of that interaction. (Doll, 1993, p. 180)

4. Rigor – Doll’s (1993) explanation of rigor takes on an expanded definition that has come to be known in the modernistic educational world. It represents never being satisfied with an outcome. “One must continually be exploring, looking for new combinations, interpretations, patterns...different alternatives, relations, connections” (p. 182).

The comparison between Doll’s (1993) description of a transformative curriculum and the previous discussion of a Multicultural Science curriculum are strongly connected, as demonstrated in Figure 1. The circle represents how this is a cyclic relationship that depends and builds upon the next. “Transformative action is the highest goal of multicultural education” (Howard, 2006, p. 82). It is the final piece in the approach to multicultural education curriculum reform, as defined by Banks (2004).



*Figure 1.* The connection between the characteristics of Multicultural Science (Barba, 1998) and the “4 R’s” of a Transformative Curriculum (Doll, 1993).

In order to accomplish the transformative action from WMS to a Multicultural Science approach, teachers must also be able to grasp the additional connections that the Nature of Science provides.

**Nature of Science.** The transformation into Multicultural Science from a Western point of view is not an easy task. It takes open-mindedness, professional development training, mentoring, collaboration with other teachers, practice, self-efficacy, and the realization that effective change happens by taking one step at a time. Using the Nature of Science (NOS) as a catalyst is one of the most successful methods of crossing this border. A leader in this research area, Norman Lederman (2003), characterizes NOS as having the following qualities.

- *There is a difference between observations and inferences.* “Observations are descriptive statements about natural phenomena that are ‘directly’ accessible to the senses...and about which several observers can reach consensus with relative ease” (Lederman, 2003, p. 833). For example, a friend’s shirt may be described as blue, a T-shirt type, and very wrinkled. Inferences are beyond the senses, in that they may give a possible explanation for the observation, e.g., my friend’s shirt is wrinkled because he slept in it! The task of understanding the difference between an observation and an inference is directly related to multicultural science. As observations are made, in-depth discourse, which is the heart of the activity, pull students into “negotiated passages” i.e., students openly discuss the reasoning behind their inferences with other students who may have different interpretations (Doll, 1993, Gergen, 1991). All students then “negotiate” what could be the most reliable inference, listing their reasons for such. Referring back to my first example, perhaps my friend’s shirt was wrinkled because it was lying in the clothes dryer all night.
- *Theories and laws are different kinds of knowledge, and one does not develop or become transformed into the other.* “Laws are statements or descriptions of the relationships among observable phenomena. Theories, by contrast, are inferred explanations for observable phenomena” (Lederman, 2003, p. 833). To illustrate this point, one can *observe* the effects of the *law* of gravity, but the dominant *theory* of gravitation was developed from numerous observations and inferences as well as mathematical formulations, and so cannot be observed in the same way.

Once again, the correlation to multicultural science is obvious—making sense from observations through group discourse, drawing new inferences, and exploring to see if these inferences could be proven true.

- *Science is creative.* This principle aligns with very closely with Multicultural Science. Science is not a discipline that urges us to read, memorize, and recite; rather it is an enterprise that encourages us to use our intellect to solve real world problems—“to create, to invent, to build, and to develop new ideas and ways of thinking” (Barba, 1998, p. 7).
- *What we know about science is tentative.* NASA acknowledges that the shelf-life of new information that is harvested with current technology is approximately one week or less.

We can anticipate data collection volumes to grow to a yottabyte ( $10^{24}$  or  $2^{80}$ ) in volume by the year 2015. This is two hundred times more bytes of data than all the stars in the Universe. Where the Greeks were ‘thinking big’ to conceive of libraries containing treasures of knowledge, we must begin ‘thinking big’ to conceive of how we can exploit all the knowledge that we have accumulated over the millennium and that now is multiplying at exponential rates with today’s technology explosion. (Dwivedi & Callicott, 1999, p. 1)

Multicultural science acknowledges changes in nature and the vast amount of information yet to be discovered. Gary Witherspoon, as quoted by Cajete (2000), explains this concept from the Native American paradigm. The assumptions that underlie this dualistic aspect of all being and existence is that the “world is in

motion, that things are constantly undergoing processes of transformation, deformation, and restoration, and that the essence of life and being is movement” (p. x).

- *Scientific knowledge is subjective.* If, indeed, NOS relies on inferences being based on observations, then a logical concern follows if there are conflicting observations leading to disputed inferences. Chalmers (1999) explains that what one sees is not necessarily what another person sees. Examples include optical illusions and eye-witness testimony of a crime. “...what observers see, the subjective experiences that they undergo, when viewing an object or scene is not determined solely by the images on their retinas but depends also on the experience, knowledge and expectations of the observer in science” (p. 7).
- *Science is a culture—and scientists are the product of that culture.* Elements of this culture include political ideologies, religion, society, philosophy, socioeconomic influences, and structures of power. All of these elements could be factors that promote or deter Multicultural Science as a viable curriculum movement. (Lederman, 2003)

These noted characteristics of NOS are profoundly connected to Multicultural Science as a building block for science curriculum as well as the overall environment of the science classroom. Acknowledging that science is a culture of itself brings sensibility to the notion of “border crossing” (i.e., being able to successfully integrate home and school culture), which is necessary for the Multicultural Science classroom. Teachers can begin the process of border crossing by being cognizant of their students’ views and knowledge of the world (i.e., their cultural capital). “A culturally responsive pedagogy

recognizes that all children bring some knowledge into the classroom and makes links to the everyday lives of diverse students, their family and friends, and the subculture of science and mathematics” (Rodriguez & Kitchen, 2005, p. 89).

In moving forward toward a multicultural science classroom, how do teachers transform the WMS/Eurocentric way of teaching science to one which is culturally congruent to the class as a whole? Deering (1996) contends that the [multicultural] curriculum must be one “that is rigorous, integrated; student-driven and real-world-based—far more than ‘food, fiestas and fashion’ that are all-too-common as multicultural curriculum” (p. 24). In the following section, Multicultural Science instructional strategies will be addressed. Furthermore, the physical and social components of a classroom using these strategies will be described, specifically toward the development of a transformative, culturally congruent curriculum experience.

### **The Multicultural Science Classroom**

**Constructivism and social constructivism.** The constructivist paradigm is self-descriptive. It is rooted in the belief that humans gain knowledge by building and rebuilding on experiences. New knowledge is acquired by linking prior experiences to the new concepts presented (Barba, 1998; Garcia, 2004). Furthermore, this construction of knowledge is literal in that one learns by doing—e.g., exploring, testing, researching, and reflecting on their work (Cajete, 1999; Cobern, 1994; & Luykx, 2007). “The one-way transmission model of the teacher imparting knowledge to students is contrary to the constructivist conceptualization of learning. The student’s knowledge base and personal experiences become key factors in the learning of science” (Hines, 2005, p. 7).



One of the earliest proponents of expanding the constructivist paradigm was Vygotsky (1978), who proposed that students learn by interacting within a social network (social constructivism). Vygotsky contended that learning occurs first in the social realm, and secondly, in the individual experience. Simply stated, social constructivism requires face-to-face interactions, which (according to Vygotsky) are the origins of higher mental functions (Jacob & Phipps, 1999).

Therefore, it certainly makes sense that many researchers agree that constructivist and social constructivist methods of teaching are critical for success in the Multicultural Science classroom (Barba, 1998; Cajete, 1999; Cobern, 1996; Doll, 1994; Eldering & Leseman, 1999; Gay, 2000, 2003; Hines, 2005; & Luykx, 2007; Rodriguez & Kitchen, 2005, Vygotsky, 1978). According to Barba (1998), the constructivist and social constructivist frameworks are highly appropriate pedagogical approaches in the Multicultural Science classroom because they:

1. provide multiple means of data representation,
2. allow for peer tutoring, provide for the use of home language in small groups,
3. allow students to bring culturally familiar examples and elaborations into the classroom,
4. permit students to interact with manipulative materials, encourage students to work cooperatively in constructing new knowledge,
5. and ‘fit’ with what is known of the learning/teaching process (from research in cognitive psychology). (Barba, 1998, p. 21)

**Narratives and discourse.** According to Geneva Gay (2000), a successful Multicultural Science classroom begins with a story. “Narratives encompass both the modes of thought and texts of discourse that give shape to the realities they convey,” (p. 2). Stories promote a use of language in the science classroom and are important for students of color to share and identify with other students. Barba (1998) contends that “native language in the classroom (1) builds students’ self-esteem, (2) improves students’ attitudes toward schooling, (3) facilitates content area acquisition of declarative knowledge, and (4) aids in mainstream language development” (p. 16).

Additionally, Doll (1993) explains that a good story (narrative) requires interpretation, and subsequently engages the students to enter into discourse with the text. “As teachers, we need to present our lessons in enough narrative form to encourage our students to explore with us the possibilities that can be generated from dialogue with the text” (p. 169).

**The role of authority.** Student autonomy is one of the basic tenets of a Multicultural Science classroom (Calabrese Barton, 2003; Doll, 1993). However, releasing their authority to students is one of the biggest challenges educators profess concerning a transformative, Multicultural Science program. “They [teachers] worry that without direct and constant supervision, the classroom might deteriorate into chaos...” (Cohen & Lotan, 2004, p. 744). The lineage of modernistic authority is very clear; we have been drilled in the “chain of command” from our earliest memories. One answer to this conflict is the use of cooperative learning, although this concept, too, must be taught to and practiced by students. The process of learning this technique may take some time, but when students recognize this as the “norm” instead of the exceptional strategy, they

will become more efficient in its use (Cohen & Lotan, 2004). In addition to learning how to manage the roles they are assigned, they “develop important social skills highly relevant for adult life” (p.745), such as questioning, group discourse, responsibility, and time management.

Doll (1993) explains his view of control in the classroom as being two-fold: (a) external intervention and (b) internal intervention. External intervention is the control from the authority of the teacher, rooted in our modernist history, as previously discussed. Certainly, one can agree that this type of control is needed upon occasion; but, it is not conducive (as the normal procedure) to a learning environment. A student’s empowerment in his self-control (i.e., his internal intervention) is the goal of the transformative, Multicultural Science classroom. Doll refers to the teacher in this situation not as the ruling authoritarian, in charge of external intervention, but rather as the “first among equals.”

[This concept] defines the teacher’s role in a transformative, post-modern curriculum. As the first among equals, the teacher’s role is not abrogated; it is rather restructured and resituated from being external to the student’s situation to being one with that situation. The authority, too, moves into the situation. (Doll, 1993, p. 167)

Anyone who has been in a middle school science classroom might balk at this release of authority. However, as part of a changing society, our students must become proficient in “negotiating passages,” i.e., be able to work out differences of thought through discourse with their peers (Gergen, 1991), solving problems within a group (Cohen & Lotan, 2004), and exercising internal control (Doll, 1993).

**Authentic assessment.** A positivist's view of assessment is subjective and teacher centered, e.g., to demand the "right" answers to a battalion of questions. Although this method of testing is flawed (Kornhaber, 2004), quizzes/tests/exams are given frequently to students throughout their schooling. Local, state, and national standardized tests are also required of students several times a year, each alike in the directions to "bubble-in" the one best answer. Students become frustrated, confused, and simply tired of these assessments (Calabrese Barton, 2003; Hines, 2005).

In contrast to the modernistic, standardized testing method is the authentic assessment, which uses students' multiple intelligences to build portfolios, projects, or presentations for conceptual evaluation. In this sense, authentic assessment fits into the transformative curriculum paradigm.

To illustrate an authentic assessment appropriate for the multicultural science classroom, Barba (1998) describes an "Individual/Group Task Test," which is meant to evaluate each student's (or small group's) understanding of energy. The students are given poster board (for each student or group of students), magazines, colors, glue, scissors, etc. and then directed to display their knowledge of energy by making a bulletin board for the class. The project is graded using a rubric, scoring 0-3 points.

Traditional pencil-and-paper assessment has focused on the cognitive domain, on conceptual learning. Learning may be expressed through multiple modes of knowledge representation. Authentic assessment, which involves multiple means of presenting learning, ought to be incorporated into all elementary science classrooms. (Barba, p. 160)

To add to Barba's (1998) statement, authentic assessment should be incorporated into *all* science classrooms, including middle and high schools. Yet, our society emphasizes standardized testing, known to be laden with problems, as a means of evaluating our educational system. The irony is incredible, i.e., our government demands accountability from teachers proving that all children are learning, specifically the students of color who have been sorely underrepresented in higher level math and science classes and careers. However, that accountability is based on results from standardized testing, a method that has been shown as detrimental in the assessment of culturally diverse students (Barba, 1998). Therefore, the government-mandated No Child Left Behind Act's of 2001 use of standardized testing is actually leaving children of color behind in their education. It is dooming the very population it is meant to save.

This section has discussed the many aspects of a transformative, Multicultural Science classroom. Obviously, not all of the characteristics discussed in this chapter could be incorporated on a daily basis. However, following is a summary of what experts in the field of Multicultural Science have suggested for building a science program that crosses borders for ethnically diverse students.

- Academic heterogeneous student groupings,
- Groupings of students in consideration of language development,
- Languages and customs relating to the lesson discussed, Inquiry and discourse throughout the lesson—by the students and the teacher, Stories connecting the conceptual goal for the lesson—told by the teacher, by the students, or from literature,
- Conceptual connections relevant to the students, families, the communities, etc.,

- Active participation—explorations, research, creative experimentations,
- Process skills for discovery—i.e., observing, classifying, communicating, testing, recording data, inferring, etc.,
- Hands-on inquiry and discovery,
- Flexible time constraints—i.e., if a project/activity is not completed in one class session, (limited to about 45 min.), plan for students to have an additional day or more to continue,
- Scientists of color (including women) as guest speakers,
- Frequent outdoor science explorations, A variety of teaching styles,
- Authentic assessments,
- Field experiences, e.g., trips to significant sites related to the scientific concepts covered,
- Pictures, charts, “word walls” posted, which are related to the concepts covered in class,
- A teacher who is a guide, not an authoritative lecturer,
- Involved parents and community members, Involved administrators, Mutual respect, and
- Perhaps even laughter.

## **Conclusion**

The United States educational system is failing, as determined from the standards imposed by global measurements (e.g., TIMSS, PISA). Students are disconnected to schools and curriculum, specifically science. At the same time, the United States educational system has increased dramatically in its ethnic population, largely from the

country's gains in immigration. Therefore, in order to meet the changing needs of schools and society, curriculum and classroom instruction must construct new pedagogy that matches the learning styles and experiences of our ethnically diverse student populations.

In order to accomplish this task, theorists have examined a multicultural approach, i.e., a method of instruction which includes constructivist/social-constructivist paradigms; a release of modernistic/positivistic strategies in favor of post-modern, student-centered instructional strategies; and an inclusion of border crossing from students' home cultures to that of the schools' cultures.

This chapter specifically addressed the discipline of science, and how student disconnect in science (as reported by research) may also be examined through the multicultural lens, i.e., Multicultural Science Education. Its descriptors, objectives, goals, classroom characteristics, and how it differs from Western/Eurocentric Science were discussed.

In the next chapter, a review of the research literature relating to Multicultural Science from the perspectives of students, preservice teachers, and inservice teachers will be presented. Furthermore, specific questions will be developed relating to a Multicultural Science program located in an urban K-12 charter school in a large southwestern city.

## CHAPTER 2

### REVIEW OF LITERATURE

The purpose of this chapter is to review literature concerning instructional changes among culturally diverse student populations in the educational system, both in the United States and in other countries. With specific attention to the discipline of science, this section will explore research related to Eurocentric/Western Modern Science (WMS), which is traditionally taught in our public education systems, and Multicultural Science, which brings into account cultural connections with students and the curriculum. WMS in science classrooms is considered more linear in nature than Multicultural Science, which is cyclic in nature (Fixico, 2003).

In researching this topic, I used three data-bases—ERIC, Educational Full Text, and Ethnic Newswatch, as well as relevant articles acquired through course readings. Key words used in the searches included Multicultural Science, Indigenous Science, Western Science, Multicultural Science, and instructional congruence. There were approximately 200 articles that were related to these searches from 1998 to the present date. However, there were only a handful of empirical studies—of which 15 are included in this review. The remaining articles were opinion and theoretical papers, some of which will be used later to develop the design of this research.

The theoretical framework used to inform this research is instructional congruence, as defined by Luykx and Lee (2005). The instructional congruence perspective expands upon the cultural congruence literature by maintaining that effective subject area instruction should consider students' prior cultural and linguistic knowledge in relation to the specific demands of particular academic disciplines, such as science.



“Correspondingly, the role of instruction (or educational intervention) is critical in developing congruence between academic disciplines and students’ cultural and linguistic experience” (p. 426).

This chapter is organized into three sections—(a) a description of instructional congruence, (b) studies that relate to culturally diverse students (elementary through college), and (c) studies that pertain to teachers (including preservice and student teachers). Discussions and critiques will follow each of the sections. As this chapter concludes, a general discussion of implications will be presented followed by new research questions that arise as a result of gaps in the existing literature. These new questions will drive the research at hand.

### **Instructional Congruence**

For purposes of this research, the terms cultural congruence, culturally relevant pedagogies, and collateral learning are related to the theoretical framework, instructional congruence. Luykx and Lee (2007) explored the concept of instructional congruence as it relates to student diversity within the demands of academic disciplines (e.g., science). Their definition states: “Instructionally congruent teaching requires that teachers have knowledge of both academic disciplines and student diversity. . . It is to guide teachers in recognizing students’ prior linguistic and cultural knowledge and the relation of this knowledge to scientific content and practice” (p. 426).

Luykx and Lee (2007) conducted a large scale qualitative study involving 75 teachers and over 2000 elementary students, the purpose of which was two-fold. First, develop a quantitative instrument to collect large scale qualitative data in a more uniform manner. Secondly, this large scale research further clarified the properties of instructional

congruence. Themes that emerged after using the newly developed instrument included (a) the students' home language, (b) diversity of experiences, (c) giving students scientific authority, (d) linguistic scaffolding to increase meaning, and (e) the necessity of classroom discussions.

Of significant importance in developing instructional congruence is concept of border-crossing—i.e., the ability of nonmainstream students to “negotiate the boundaries that separate their own cultural environments from the culture of Western science and school science” (Lee & Luykx, 2007, p. 45). In order to clarify the cultural border crossing of nonmainstream students, Costa (as cited by Lee & Luykx) conducted a study with high school students who were enrolled in high school chemistry and earth science classes. Costa’s research identified five categories of students as they identified with their home cultures and the culture of school, specifically science. These categories included the following.

- Potential Scientists—home and school cultures are a perfect match
- “Other Smart Kids”—home and school cultures match, but not home and science
- “I Don’t Know” Students—home and school cultures are inconsistent
- Outsiders—home culture is discordant with both school and science
- Inside Outsiders—home cultures do not match, but are potentially compatible with science (Costa, as cited by Lee & Luykx, 2007, p. 45)

One interesting outcome of this research was that there were few mainstream students that universally connected home and school cultures. This suggests that border crossing with WMS and everyday life may be demanding for all students. “Although

some students may successfully bridge the cultural divide between home and school, others may become alienated and even actively resist learning science” (Lee & Luykx, 2007, p. 46).

In a longitudinal case study, Powell (1997) changed directions in his research purpose as he became engrossed in his subject’s experiences over five years. He began the research with “Amy” as she was student teaching, and concluded during her fourth year of having her own classroom. Even though Powell’s first intention was to investigate and compare Amy’s prior experiences with classroom teaching with those of her current teaching assignment, “...this study evolved into one that focused on culturally relevant teaching” (p. 472).

Powell’s methodology included a constant comparative analysis of his classroom observations, field notes, interviews with Amy, her journal writings, and reflective discussions with Amy. Three themes emerged from his data—acquiring cultural sensitivity, reshaping the classroom curriculum, and inviting students to learn.

Throughout Powell’s (1997) observations of Amy, he watched her transform into a teacher for social justice. Following is an excerpt of dialogue from Amy that Powell (1997) included in his research report. “They are in a world that doesn’t speak their language. So it is so easy to misinterpret their abilities. The system is just too quick in categorizing them, classifying them, and generalizing them” (p. 473).

Throughout the years of the study, Amy continued to find ways to culturally connect with her students. She re-shaped the standardized curriculum, provided choices to the students for assignments and/or projects, and consulted her students on how the classroom should be arranged to make learning better for them. Students described her

classroom as stress-free, non-threatening and safe, but with high expectations from their teacher (Powell, 1997). Powell concluded that his study aligned with the work of Ladson-Billings (1995), whose work with African-American students included a grounded theory of culturally relevant pedagogy.

Culturally relevant teaching, when combined with related work that calls for classroom teaching that is more responsive to the needs of diverse groups, and aligns with Giroux's idea that educators in contemporary society might best be viewed as cultural workers. (Powell, 1997, p. 469)

Herron, Green, Russell, and Southard (1995), conducted a research study in which teachers listed the barriers they perceive toward developing a culturally congruent classroom. These barriers included money, time (workload too heavy), lack of resources, lack of training, limited perspective (i.e., need for more education in cultural diversity than black/white and disability issues), hard to incorporate into the science curriculum, lack of student motivation, student intolerance of diverse cultures, and "it isn't appropriate for math and science" (p. 9). Of these participants, approximately 55% of the teachers did have some training in multicultural education, and felt it was somewhat beneficial. However, only 15% of the teachers felt they needed more training, even though this was listed as one of their barriers.

### **Student Perceptions of Multicultural Science and the Nature of Science**

**The Nature of Science (NOS).** In evaluating how Western Modern Science and Multicultural Science could "work" together within science classrooms, the Nature of Science must be considered. The perfect scenario would be for all students, regardless of culture, to understand each others' views on this topic. The Western (Eurocentric)

definition of the Nature of Science, as experienced in conventional science classrooms, is to hypothesize, experiment, and draw conclusions in a positivist manner. This is quite different with culturally diverse students, as the Nature of Science is connected to all things and in all things (Allen & Crawley, 1998; Basu & Barton, 2005; Cuevas, Lee, Hart, & Deaktor, 2004; Sutherland, 2005; Sutherland & Dennick, 2002).

Sutherland and Dennick (2002) explored the constructs of American Indian and non-Native students' perceptions of the Nature of Science through their own cultures and languages. This study used both quantitative and qualitative analysis with 72 seventh grade Cree students and 36 seventh grade Euro-Canadian students. Two teachers, who used the same textbook for teaching science, were also part of this study.

The quantitative aspect of this research used the Nature of Scientific Knowledge Scale (NSKS), which was changed (with permission from the authors) in order to make it more cognitively appropriate for the seventh grade participants.

The NSKS model covered six tenets or postulates of the nature of scientific knowledge: Amoral, Creative, Developmental, Parsimonious, Testable, and Unified. In addition, it reflected independently agreed-upon representations of the nature of scientific knowledge by three philosophers of science. Eight statements related to each of the six tenets; four of the statements were negative and four were positive. (Sutherland & Dennick, 2002, p.7)

The researchers conducted open-ended questionnaires and interviews with the students and their teachers, as well as observations in both classrooms. The findings revealed that the Euro-Canadian students leaned more heavily to the Western thought of science in their science classes (positivist interpretation of science) than the Cree

students. The interviews revealed that the Cree students include family, legends, and effects on nature to define their understanding of scientific concepts.

In a study conducted by Allen and Crawley (1998), a comparison of the Native American worldview and modern (WMS) worldview in the context of the Nature of Science included 28 Kickapoo Band middle school students and two teachers. As a qualitative study, data were collected over 18 months, including student interviews, field journals, student drawings, and “other documents” at Kickapoo Community Center and the local elementary school, an American traditional school. Only four percent of the school population was from the Kickapoo Band; the majority of students in the school were Hispanic. Their science text was also reviewed for possible positivist views.

Like the previously described study by Sutherland and Dennick (2002), the findings revealed that the Kickapoo Band students saw the Nature of Science in a different light than their teacher and other students in the class (Allen & Crawley, 1998). The teachers’ instructions and text were extremely positivistic in nature – one right answer. Furthermore, the Kickapoo students enjoyed the investigation of “why” rather than the “teacher as resource” method of learning. Traditional Western ways of teaching science included the “reductionist” ways of looking at the world—e.g., parts of a cell, steps of scientific method, parts of a plant, parts of our body, etc.

The Native approach is that of the whole—its connectedness to other aspects of nature. The Kickapoo students preferred cooperative learning rather than competitive styles of learning. As was the case in the previously reported study, the teachers viewed science as linear in nature; however, the students viewed science as grounded in the cycles of nature. [Since an overwhelming number of students at this school were

Hispanic, it might be prudent to see a second set of data and analysis that included these students.]

In a research conducted by Sutherland (2005), 20 middle school Cree students (as well as their white, middle-aged teacher) were observed and interviewed concerning educational motivation and what constitutes effective learning within the constructs of the Nature of Science. Of the 20 students interviewed, only seven could be considered “collateral learners,” meaning that they are able to cross the border between home and science environments.

Thus, since increased protective factors and collateral learning are positively related, at least in this study, then developing systems that enhance resiliency factors (such as career awareness, positive peer relationships, intrinsic and extrinsic motivational incentives) are all important in enhancing science learning.  
(p. 609)

It is interesting to note that the intrinsic motivation was greater for the collateral learners. Developing a sense of curiosity for the scientific study rather than trying to simply please the teacher helped to foster intrinsic motivation, as literal grades on assignments were not extrinsic motivators for the collateral learners. Student discussions concerning their experiences may increase intrinsic motivation, which in turn increases collateral learning.

As previously described, creativity is a component of the Nature of Science (NOS). Scientific inquiry, while not a direct component of the Nature of Science, is certainly an important element of creativity. Improving science inquiry and developing a sustained interest in scientific inquiry were topics of research for Basu and Barton (2005)

and Cuevas, Lee, Hart, and Deaktor (2005). In Basu and Barton's study, the authors drew upon qualitative case study methodology to investigate developing a sustained interest in scientific inquiry among minority youth. The main focus of this study was observing an after school invention and science exploration program for minority youth. Students in this program were observed over a four month period. Four 30-45 minute interviews were also conducted with the participants, and work was collected from the students.

The researchers found that (in this study) the students developed a sustained interest in science when they determined that it connected with their lives, they could see the purpose of science in their lives, and the learning environment was socially desirable. Again, these qualities are parts of what defines Multicultural Science—relevant curriculum which is connected to one's life, within a safe, conducive learning atmosphere.

The second study (Cuevas, et al., 2005) concentrated on a program designed to improve student inquiry, a component of creativity within the Nature of Science. Seven teachers and 28 third and fourth grade Black and Hispanic students were chosen for this intervention program. Students and teachers were taught the basics of asking relevant questions and designing experiments to solve problems. After each problem was "solved," new questions were developed from that discovery and exploration. Quantitative data were collected using pre and post tests for developing skills in inquiry. The results were quite interesting. "Significance tests of mean scores between the pre and post elicitations indicate statistically significant increases in students' ability to conduct inquiry in general and to employ each of the specific skills of the inquiry framework" (Cuevas, et al., p. 347).



The final study concerning the Nature of Science is quite contradictory to the ones just cited. Students' views concerning the NOS were explored by Kang, Scharmann, and Noh (2004). The study took place in Seoul, Korea with 534 sixth graders (randomly drawn from five elementary schools within the 11 different school districts in Seoul), 551 eighth graders, and 617 tenth graders chosen from schools with similar socio-economic backgrounds.

A multiple choice survey was given to all 1072 students and quantitatively analyzed. "The questionnaire consisted of five items that respectively examined students' views on five constructs concerning the NOS: purpose of science, definition of scientific theory, nature of models, tentativeness of scientific theory, and origin of scientific theory" (Kang, Scharmann, & Noh, 2004, p. 314). Additionally, students were given a questionnaire containing open-ended questions pertaining to scientific reasoning, e.g., "What is scientific theory?" (p. 321). The multiple choice surveys were tabulated using chi-square statistics, and coding for themes was used for the open-ended portions.

Results proved to be significant. Overwhelmingly, the students expressed that science is only valuable when it can improve our lives. Their definition of theory was that it is a plausible, yet not proven fact. The majority of students had an absolutist and/or empiricist perspective about the NOS. There were no clear differences in sixth, eighth, or tenth graders. This culture (non-Euro-American) viewed the Nature of Science the same as those of WMS pedagogical thought.

**Barriers perceived by students of diverse cultures.** The last research of this section concerns the barriers that culturally diverse students and their teachers consider to be detrimental to their educational goals. Hoffmann, Jackson, and Smith (2005) explored

this concept with 29 American Indian secondary students from the Navajo Nation. Data sources consisted of 30 minute interviews with students with set questions (included in the report) concerning career desires, barriers that would hinder their choices, and how they thought they could overcome the barriers. The interviews were unstructured, however, so that further discussions could emerge. Interviews were recorded and transcribed, then interpreted by the researchers “using a hermeneutic qualitative method” (p. 35). Analysis was conducted in three steps—(a) unfocused reading of the text, (b) interpretations through successive readings of the text, and (c) explanation of the findings, i.e., identifying themes. Each researcher analyzed the text independently following the above procedure, and then met with the other researchers to compare findings toward a consensus of identified themes.

There were both surface themes and complex themes identified. Surface themes included (a) a limited range of possible careers, (b) barriers—a lack of money, their family, peer pressure, and a lack of science knowledge or choice, (c) no perceived barriers—which is a barrier in itself by not recognizing or caring about the problems, and (d) strategies to overcome barriers. Stated strategies included getting academic help from teachers and/or parents, soliciting family support, working harder in school, and seeking financial aid. Complex themes that surfaced were the ease of getting a job, the lack of concern or knowledge about barriers, and the pressure to conform to perceived social pressures imposed by peers and/or family.

### **Perceptions of Teachers (Preservice and Inservice)**

The perceptions of teachers for Multicultural Science education are of great importance. Just as students’ preconceived ideas influence their learning, teachers’ prior

experiences and/or attitudes certainly influence their teaching. Included in this section are eight studies, three of which were conducted with preservice teachers (Atwater & Crockett, 2003; Brand & Glasson, 2004; & Calabrese Barton, 1999), while the remaining five evaluated beginning or full time classroom teachers (Aikenhead & Huntley, 1999; Bianchini & Solomon, 2003; Lee, 2002; Lee, Hart, Cuevas, & Enders, 2004; Luft, Bragg, & Peters, 1999).

**Perceptions of preservice teachers.** Atwater and Crockett (2003) explored prospective teachers' education world view along with their teacher education programs. The purpose of this study was to "chronicle events through interviews in participants' lives as they related to culture, class, and ethnicity" (p. 61), and to reflect on the findings in relation to the participants' life histories and teacher education. Three White male students pursuing Masters' degrees in education were chosen as participants because their majors were science education. Each of the three participants was interviewed one time with 12 open-ended focus questions, e.g., "What do you think culture is?" (p. 64). Triangulation was claimed by the authors through interviews with the students, conversations with other professors concerning the students' backgrounds, and both authors analyzing the data.

Three assertions were made by the authors: (a) "Notions of ethnicity and culture are different; however, ethnicity includes culture, (b) Self-identity is contextually bound by cultural, ethnic, and class experiences, and (c) Educational world view is created from family, community, and schooling experiences and through the lens of identity" (Atwater & Crockett, 2003, pp. 68-72). One participant explained, "I was shortchanged in a sense

as a student in that I was surrounded by homogeneity all the time” (p.75). This participant felt that his teachers could have taught him more about other cultures.

One of the limitations to the study was that there were only three participants from the same class (and university), so diversity was an issue. Also, the “triangulation” of data was somewhat suspect. Having the second author analyze the data is not another source of data, although another perspective could be worthwhile. Another identified limitation, which was quite interesting, was that the White students generally did not know their ethnicity or even believe it was important. They considered themselves to be American, not (for example) Irish American or German American. This limitation could affect the discussions, since the White students may not even understand the concept of culture or ethnicity.

Cultural knowledge is a critical factor in cultural identification. Furthermore, “cultural identification serves as a powerful filter in the participants’ lives and their educational world views” (Atwater & Crockett, 2003, p. 78). Therefore, science teacher educators and preservice teachers must have the knowledge and skill to be able to assist their students’ cultural interpretations of their experiences. Further studies are warranted, including those that address the question: “How do culture, ethnicity, race, gender, and geographical region affect science teachers’ actions in their classrooms?” (p. 80).

Another study that explored preservice teachers’ attitudes toward Multicultural Science was conducted by Calabrese Barton (1999). The author asked for volunteers from her summer multicultural science education class to do a service project with a shelter for battered and abused women and children. The purpose of this case study was

to determine what effect community service learning has on preservice teachers, specifically in the construct of multicultural science.

The participants were eight graduate students—seven women and one man. There were four White Americans, one Pakistani, one African American, one Latina, and one Asian American. I include this information since the students are part of a multicultural science education class, and it may be relevant that they are a class of culturally diverse students. As a participant observer, the researcher conducted 30-45 minute interviews with all eight participants prior to the beginning of the course. Additionally, she reviewed the preservice teachers' journals of their teaching experiences, her participant observer field notes of science instruction with the students, and interviews with participants at the end of the study. Multiple data sources were collected, ensuring a triangulation of data.

Views of preservice teachers concerning multicultural science became more complex over the course, as described by one of the preservice teachers. Multicultural science, which takes into account each student's cultural contributions to scientific concepts, was also linked to school issues such as power, control, and school politics. The fear of teachers losing control was one of the most repetitive themes in this research. Participants also became aware of how their beliefs influenced their relationship with their students, e.g., moving from science centered to student centered. Transformation of this depth must be from inside oneself. Teachers are responsible for meeting the needs of their students, so teachers must understand and integrate student experiences into their science lessons.

“Although is it my hope that this barrier [that of positivistic science education] will come down, it seems that the structure of schooling helps to keep this barrier intact”

(Calabrese Barton, 1999, p. 312). This type of community service opened the context of doing science and teaching science through the dimensions of a multicultural approach. As students in the Multicultural Science college class learned firsthand the strategies involved with teaching in the MS paradigm, and were able to put them to work immediately with the students at the shelter, a deeper, more complex understanding of cultural and instructional congruence surfaced. “Now, I think Multicultural Science education is about a way of thinking about science and it’s a way of doing science. It is open to alternative frameworks and also challenging. It’s open-mindedness” (Calabrese Barton, 1999, p. 308).

The final research pertaining to preservice teachers was conducted by Brand and Glasson (2004). Like the Atwater and Crockett (2003) research, there were only three participants (all male) in this ethnography; however, unlike the aforementioned study, these 3 participants were of diverse ethnicities – an Asian American, an African American, and a Rural U.S. Appalachian.

In crossing cultural borders, preservice teachers are challenged to become consciously aware of their preexisting beliefs and life experiences as related to their own racial and ethnic identities. As teachers assimilate new subcultures, they may experience collateral learning in which they experience cognitive conflict with their existing belief system. (Brand & Glasson, 2004, p. 121)

Students in this particular method’s class were required to participate in a small amount of classroom teaching. Data were collected from teaching observations, reflective journaling, and interviews. The authors investigated whether the preservice teachers’ prior beliefs concerning their own cultural identity influenced how they taught in their

classrooms, specifically in science. Findings revealed that early life experiences, current life experiences, and experiences with diversity in the teacher education program all influenced the preservice belief systems concerning teaching in a culturally diverse setting. This is such a profound study, because university science methods instructors must recognize that their preservice teachers come to class with preconceived attitudes and beliefs about science in general as well as Multicultural Science.

**Perceptions of inservice teachers.** As preservice teachers move into their new world of teaching, what perceptions about the Multicultural Science pedagogy do they carry to the profession? Do these perceptions change with the number of years that teachers are in the classroom? Do seasoned teachers continue their positivistic instructional strategies even though the diversity of students in their classrooms has changed dramatically over the years? If we include government policy into this mix, then Multicultural Science, i.e., instructional congruence, becomes even more complicated.

In addressing this point, Shaver, Cuevas, Lee, and Avalos (2007) conducted research with seasoned teachers concerning imposed state standards, state assessments, and subsequent teacher accountability. Questionnaires, interviews, and focus groups were part of the mixed methods, two year longitudinal study of 43 third and fourth grade teachers from six elementary schools. The schools had high populations of English language learners and were located in a large urban city in the southeastern United States.

Although positive about the standards and objectives that they use in daily instruction and planning, the teachers balked at the state assessments and the teacher accountability that accompany the assessments. They saw that teaching was no longer for the joy of learning, but for the drilling preparations of the tests. If science and/or social

studies were to be included in day's agenda, it would have to be reading about science and/or social studies. These participating teachers believed that students with low English skills (culturally diverse students) were at a large disadvantage—not only in the testing, but in losing good instructional time in the classroom because of the testing. Is it possible that policy actually sets students up for failure?

Aikenhead and Huntley (1999) looked at experienced teachers' views on combining Western and Indigenous science in their science classes with Native students. Additionally, the authors investigated science teachers' cultural awareness of WMS and its connection to Indigenous home culture with the science taught in the classroom. "This connection, or 'nexus', between a community's culture and the culture of Western science is captured by the phrase 'science and culture nexus' (SCN)" (p. 164).

Participants in this mixed-methods study included 42 teachers of First Nations students in grades seven through twelve from northern Saskatchewan, Canada. Questionnaires were given and interviews were conducted over an unspecified time period. The question before these teachers was, "What happens when students move from their everyday culture into the culture of school science?" (Aikenhead & Huntley, 1999, p. 164).

The research concluded that most of the participating teachers did not recognize a conflict between Western Modern Science (WMS) and Indigenous Science. Teachers gave shallow excuses for Indigenous students failing in science or not pursuing science careers—e. g. poor language and math skills or a lack of self-confidence. These teachers did not have the resources (and/or knowledge about the students' culture) to make their mandated science curriculum cross the border to a more culturally inclusive science.



Even though Aikenhead and Huntley (1999) found that very few respondents gave evidence of cross cultural teaching, several teachers expressed that it was important to make connections between the students' everyday lives and science content. However, they also noted that it was not happening.

Another interesting finding from this research was that most of the teachers had no idea why their students did not pursue scientific careers. Aikenhead and Huntley's findings (1999) align with suggestions from Bianchini and Solomon (2003) that "teachers need to develop ways to encourage students [of color] to continue in science. Instruction and assessment [incorporating Multicultural Science strategies] should be conventional practice rather than the celebrated exception" (Bianchini & Solomon, 2003, pp. 180-181).

Following are five recommendations from Aikenhead and Huntley (1999) as a result of this research.

- Schools must validate cultural science.
- The connections with Western and Multicultural science should be evident in science lessons.
- Teachers who are successfully implementing border crossing should form a network for other teachers to contact.
- There should be National funding for the network of teachers to further educate teachers about cultural science.
- Children in elementary grades should have many experiences with materials and nature through hands-on investigations.

The past two studies have been discouraging in implementing a Multicultural Science curriculum throughout our country. How can teachers be influenced toward a

change in their teaching strategies? Two research articles— Lee (2002) and Lee, Hart, Cuevas, and Enders (2004)—address the issues of change as it relates to educating teachers in instructional congruence and their involvement in professional development.

Lee (2002) conducted research in a large urban school district in the southeastern United States. The study included six teachers who worked with fourth grade students at two elementary schools. Curriculum was developed to overcome language barriers, and professional development was designed to help teachers understand and practice instructional congruence. Specifically, the professional development addressed the language barriers present within the school population. Researchers used qualitative methods in observing classroom instruction and activity, as well as individual and focus group interviews.

The results were gratifying. All the teachers involved in the research stressed the importance of science learning for their students. Also common among the findings was that the teachers' first anxieties toward teaching science had disappeared. Teachers also practiced what they believed, i.e., they became more culturally aware and involved with their students. "To establish instructional congruence, it is critical that teachers have adequate knowledge of the subject and the ability to teach it" (Lee, 2002, p. 77).

The second study relating to professional development with teachers was conducted by Lee, Hart, Cuevas, and Enders (2004). Participants in the research were 53 third-and-fourth grade teachers at six schools. All but two teachers were female, and less than half of the teachers listed English as their native language.

The professional development for the teachers concentrated on inquiry-based science, one of the components of Indigenous Science. Three sessions of the professional

development were planned—(a) inquiry-based science, (b) incorporating English language and literacy into specific science lessons/activities, and (c) the role of students' home language and culture in classroom science instruction. At the close of the three workshops, data collection began, which included focus group interviews, questionnaires, and classroom observations.

Findings in this research indicated that the professional development did have an impact on the methods the teacher-participants used for structuring their science lessons. The teachers reported that the professional development had also affected them personally—i.e., growth in knowledge of content and growth in confidence, as well as having a more positive view of science. Finally, teachers also reported that the professional development helped them in implementing appropriate instructional strategies with other subject areas. Therefore, it appears that participating teachers learned how to incorporate instructional congruence into their instruction, which builds on the research by Lee (2002).

Two limitations to this research were named:

- (a) Validity would have been higher if more interviews with teachers had occurred (only two per teacher per year); and
- (b) There was an absence of a control or comparison group. Although these limitations are valid, they are also common with this type of research.

### **Summary and Ponderings**

Students of color consider barriers to their educational goals to be poverty, isolation, lack of proper educational preparation, and bad advice/influences from their family and friends. These perceived barriers tie into the large drop-out rate of culturally

diverse students (Clark, 1999; Carter, Larke, Singleton-Taylor, & Santos, 2005).

Additionally, the lack of success in higher level science classes inhibits culturally diverse students in pursuing scientific careers.

All too often, at the elementary school level, usually around the middle school grades, many students, especially minority students, learn to dislike or fear science and mathematics and take only the minimum required courses in these subjects at the junior and senior high school levels. The damage done is incalculable. They emerge from elementary and secondary schools without an adequate grounding in science and mathematics. Even if they become interested in the subjects in later grades, it is often too late to take the courses necessary to pursue careers in the fields of science and mathematics in college. (Clark, 1999, p. 41)

One of the biggest differences in the myths or misconceptions concerning Western Modern Science and Multicultural Science is defining the Nature of Science. Misconceptions perpetuate the myth that WMS views for school science education are linear in nature, e.g., there is one right answer, and the way to discover any scientific truth is by following the “prescribed” Scientific Method, the five to seven steps that are spelled out on many science classroom displays. Multicultural Science emphasizes the active exploration (using observations and inferences) of scientific inquiry, creativity, and the tentativeness of science—all components of NOS.

The reviewed literature in this section produced evidence that Multicultural Science curricula engage students, teachers, families, and communities. Findings in this writing were at times somewhat negative —e.g., the number of teachers who have no

knowledge of their students' "cultural capital," the number of teachers who continue to teach within a positivist framework, and the complacent attitudes of teachers concerning their resistance to change. However, it is encouraging to find teachers who are embracing the idea of cultural congruence in science education. These teachers understand that connecting a science curriculum and classroom environment that crosses the cultural border from home to school may, indeed, be the key to finally realizing "science for all" in our schools.

### **A Gap in the Literature**

There are many topic papers and books written on multicultural science—its benefits to our students and their future—yet only a handful of empirical studies exist. Certainly, this is a topic which needs more exposure through research. Specifically, many of the Native American studies were conducted in tribal schools, and revealed a large disconnect from Western science. Furthermore, this was also evident in research showcasing Hispanic and African American classrooms. (I would also suggest that many Caucasian students are also disconnected from Western science, since society reflects a more diverse culture than Western science acknowledges.) "It may also benefit science education if science educators would research the effect of cultural inclusion on the various curricula and disciplines during the current science reform" (Key, 2005, p. 99).

Powell (1997) conducted a longitudinal research on the transformation of Amy, a middle school science teacher. He observed her transition into a culturally responsible teacher over 5 years and shared her beautiful story—one filled with reflection on her teaching techniques, her student interactions, and her students' needs for a meaningful science education experience. Since Amy and Powell had worked together prior to this

research, she had a clear view of his study's goals and expectations. The case study proposed here will build on this research in order to inquire how "teachers unaware" view their teaching techniques to be successful with an ethnically diverse population of students.

The Global Community Program is an elective course for multi-age students at a culturally diverse K-12 charter school. One class in particular, the Robotics class, exhibits the qualities of Multicultural Science. Therefore, in consideration of the lack of Multicultural Science programs, the review of literature disclosing a small amount of empirical studies, and the call for more research in this field, I proposed the following research questions.

1. What evidence of a Multicultural Science curriculum program is present in the Robotics class of the Global Community Program, as practiced and perceived by the students and their instructor?
2. What are the students' attitudes toward science, specifically with the Robotics class in the Global Community Program?
3. What responses do students have to the instructional pedagogy and learning strategies used with a Multicultural Science curriculum?

## CHAPTER 3

### METHODOLOGY

Chapter 1 introduced the paradigm of Multicultural Science (MS). Its components consist of a transformative curriculum (Doll, 1993) that is culturally congruent, student-centered, inquiry driven, constructivist in nature, and personally relevant. Furthermore, Multicultural Science is rooted in the theory of social constructivism, where students construct knowledge together within their “negotiated passages” (Gergen, 1991).

Chapter 2 was a review of the research literature, in which gaps in the research program of Multicultural Science were identified. Most of the published research reports concerning MS have been opinion papers and curriculum development suggestions. In comparison, few empirical studies concerning MS are available, and those that do exist basically report on curriculum development in tribal and/or predominantly indigenous school populations. Missing in current research is that of a MS curriculum and its instructional strategies being conducted in a *public school setting*, serving a variety of diverse cultures in the student population.

The present research study addressed this gap by investigating such a program, a Robotics science class at an urban K-12 charter school. As previously discussed in chapter two, this class was part of a multi-aged Global Community Program, unique to this school, and fits the criteria of the transformative Multicultural Science paradigm. Prior to examining the details of this program—its goals and participants—a discussion of the theoretical framework for this study follows.

## Theoretical Framework

The theoretical framework for this research was instructional congruence. As stated previously, instructional congruence deals with processes: e.g., the process of adjusting classroom practices to include all cultures within that classroom, the process of relinquishing the power of the linear methods of instruction, and the process of continuously working to connect curriculum to students' lives. "This framework highlights the importance of developing *congruence*, not only between students' cultural expectations and norms of classroom interaction but also between students' linguistic and cultural experiences and the specific demands of particular academic disciplines, such as science" (Lee & Luykx, 2007, p. 76).

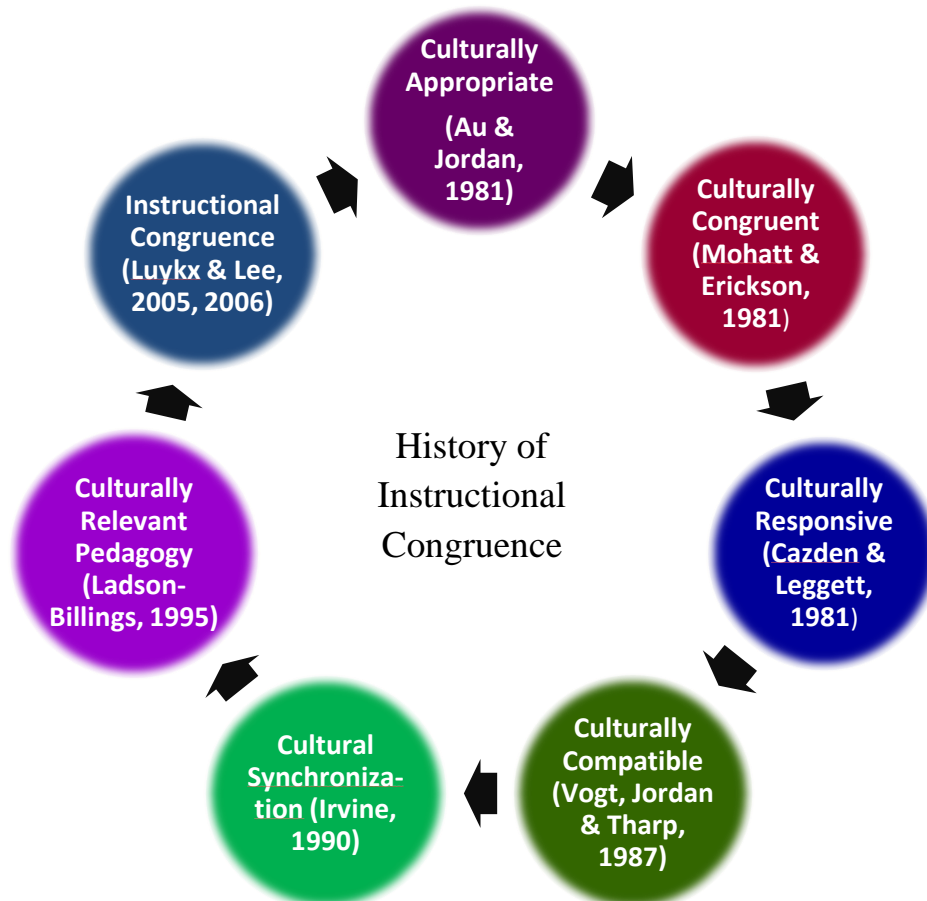


Figure 2: The history of instructional congruence, the framework for this case study.



For many years, students of diverse ethnicities have been expected to follow the Western Modern Science (WMS)—positivistic ways of learning science. They are expected to come to science classes with a certain amount of content knowledge, as well as the ability to ask questions, form hypotheses, conduct investigations, and articulate explanations using scientific terms (Lee & Luykx, 2007). As these practices do not align with the diverse cultures represented within a science classroom, many students of color have not been successful in crossing borders, i.e., adjusting to the more linear approach to science. Instructional congruence is related to educational power and justice. The power must be shared, which is actually what defines justice (Calabrese Barton, 2003).

Hawkins and Thompson (2007) continue to describe this framework as one that recognizes non-dominant groups who have been “subjected to *reculturalization*, or attempts to assimilate them into the dominant culture” (p. 287). Native American children were subjected to this practice in the early 1900’s, as they were taken away from families to boarding schools to attempt their reculturalization. This practice continues today (more subtly) when public schools, which hold positivistic views close to the science curriculum’s heart, do not accommodate the different cultures within their walls.

Instructional congruence is accomplished by a transformative curriculum paradigm, in which a transition from WMS to Multicultural Science is incremental. In order to explain this model, Fradd and Lee (as reported by Luykx & Lee, 2007) proposed the “*teacher-explicit to student-exploratory continuum*, which takes into account students’ cultural backgrounds as well as previous science experiences” (p. 77). Teachers gradually move from a more direct instructional model to a more student-centered approach to learning. Students are encouraged to take initiative in exploring their own

hypotheses and (in doing so) take responsibility for their learning. “Along this continuum, teachers should consciously maintain a balance between teacher guidance and student initiative, as they make decisions about when and how to foster students’ responsibility for their science learning” (p. 77).

Germane to the paradigms and framework of this research is social constructivism, previously discussed in Chapter 1. Crossing the border between a positivistic curriculum and one that is socially constructive in nature is a daunting, yet possible, task. Bredekamp and Rosegrant (1992) proposed that each perspective on curriculum development is important, but it is only in the interaction among the different perspectives that their true value is realized. Four properties the authors contend define a curriculum within a socio-cultural context are as follows:

1. Conceptual organizers to ensure meaningfulness,
2. Child development knowledge to enhance age appropriateness,
3. Disciplined based knowledge to ensure that curriculum has intellectual integrity, and
4. Developmental continuum to ensure the curriculum is individually appropriate.

The Robotics science curriculum, experienced by students in the Global Community Program at Tomorrow’s Future Charter School (TFCS, a pseudonym<sup>1</sup>), fits in the socio-cultural context as described by Bredekamp and Rosegrant (1992) and the teacher-explicit to student-exploratory continuum, developed by Fradd and Lee (cited in Luykx & Lee, 2007). Therefore, in consideration of the instructional congruence

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<sup>1</sup> The name of the school and all participants are pseudonyms in order to protect confidentiality. Numerical coding of students in the surveys used in this research was matched to their pseudonyms.

theoretical framework described above, I conducted a qualitative research approach for the unique, Multicultural Science program at TFCS (Bogdan & Biklen, 2003; Corbin & Strauss, 2007; Creswell, 2007; Denzin & Lincoln, 2005; Marshall & Rossman, 2010; Merriam, 2009; Patton, 2001; Weiss, 1998; Yin, 2008).

### **Qualitative Research Approach**

Defining qualitative research is a task in its own right. However, Denzin and Lincoln (as cited by Creswell, 2007) define this approach as naturalistic and holistic.

Qualitative research is a situated activity that locates the observer in the world. It consists of a set of interpretive, material practices that make the world visible.

These practices transform the world. They turn the world into a series of representations, including field notes, interviews, conversations, photographs, recordings, and memos to the self. At this level, qualitative research involves an interpretive, naturalistic approach to the world. This means that qualitative researchers study things in their natural settings, attempting to make sense of, or interpret, phenomena in terms of the meanings people bring to them. (p. 36)

Certainly, in this explanation of qualitative research, there is a key word that connects the purpose of this study with the qualitative approach—transform. This transformation occurs when observations and interpretations bring new meaning to curriculum and instructional strategies in classrooms—specifically for this study, in science classrooms. Mertens (2009) explains that qualitative methodology is critical in a transformative research—especially that of dialogue. Mertens also contends that the ontology for transformative research is rooted in social constructivism, which is most aptly described within the qualitative context. This transformative, qualitative approach

has the ability to adequately describe those people who have been marginalized within our society.

The transformative sense of ontology embraces a conscious awareness that certain individuals occupy positions of greater power and that individuals with other characteristics may be associated with the higher likelihood of exclusion from the decisions about the accepted definition of what exists. (Mertens, 2009, p. 53)

Several types of qualitative research exist, which also carry multiple meanings for research evaluation. A short description of five types identified by Creswell (2007) follows.

- Ethnography—research that centralizes on an entire cultural group and how they interact with each other over time. The researcher is an active participant observer, i.e., he/she is immersed in the day-to-day activities of the members of that culture, conducting interviews and observations (Creswell, 2007). In this qualitative approach, culture may or may not be concentrated on strictly the ethnicity; the culture could be teachers in an entire school, a group of women engineers, or the doctoral students at a particular university (Strauss & Corbin, 2007; Weiss, 1998; Yin, 2008).
- Phenomenology—research which attempts to explain events and interactions with ordinary people in particular situations (Bogdan & Biklen, 2003).

“Phenomenologists believe that multiple ways of interpreting experiences are available to each of us through interacting with others, and that is the meaning of our experiences that constitutes reality. Reality, consequently, is socially constructed” (Bogdan & Biklen, 2003, p. 23).

- Grounded theory—research rooted in the transition from the quantitative methodology, which dominated research prior to the 1970’s, toward the qualitative approach (Charmaz, 2006). In order to make this transition, Glasser and Strauss, two theorists at the forefront of this methodology, used their research to link to other social processes—the goal of which was to establish new theory. Its descriptive, narrative observational data is coded as it is collected and constantly compared to reach this theoretical development. “Since the data drives the research outcomes, the literature review is conducted after developing an independent analysis” (Charmaz, 2006, p. 4).
- Narrative research—research with one or two individuals using data that are gathered from the participant’s stories. Different types of narrative research include biographical studies, life histories, and oral histories (Creswell, 2007). “Narrative is understood as a spoken or written text giving an account of an event/action or series of events/actions, chronologically connected” (Czarniawska, 2004, p. 17).
- Case study—research that is used “when ‘how’ or ‘why’ questions are being posed, when the investigator has little control over events, and when the focus is on a contemporary phenomenon within some real-life context” (Yin, 2009, p. 2). Case studies use multiple sources of information—e.g., observations, interviews, audiovisual material, and documents—to develop a case description with case-based themes (Creswell, 2009).

As these types of qualitative research are examined, they all contain components of a transformative, constructivist approach. Similarities include understanding the

essence of an experience, telling the stories of experiences, studying a process, and describing and interpreting a culture-sharing group (Creswell, 2007). In deciding the type of qualitative design to use, I more closely evaluated the work of several experts in the field of research—i.e., Creswell (2007, 2009), Merriam (2009), Stake (1995), and Yin (2009).

Yin (2009) explains that a case study is bound by three conditions: “(a) the type of research question posed, (b) the extent of control an investigator has over actual behavioral events, and (c) the degree of focus on contemporary as opposed to historical events” (p. 8). In a case study, the how or why questions are used to investigate an in-depth description of a process within a social context. Questions within this study met these criteria—to understand how this particular Multicultural Science program incorporates socially constructed methods toward an instructionally congruent learning environment.

Merriam (2009) describes a case study as “a basic qualitative study” (p. 22). The overall purpose of such a design is to understand the impact of constructed experiences within a social context. Furthermore, Merriam describes this type of qualitative research as being bound, i.e., the researcher is looking at one phenomenon—one part of a phenomenon—one particular program. “If the phenomenon you are interested in studying is not intrinsically bounded, it is not a case” (p. 41).

In his descriptions of case study, Stake (1995) actually divides this type of qualitative research into two categories. The first, the intrinsic case study, is defined as studying one particular phenomenon for the sake of understanding only that particular phenomenon. The researcher is not looking to apply results of the case study to anything

else outside of that phenomenon. The second type of case study identified by Stake (1995) is the instrumental case study. This type of case study looks at a particular phenomenon in order to answer a unique question that other researchers have also pondered. Therefore, it may build upon or be instrumental to understanding or describing (for example) a particular paradigm of teaching science to students of diverse cultures.

In review of the questions and purpose for the research at hand, the instrumental case study approach was the most appropriate. Since I conducted research looking at the particular phenomenon of instructional strategies incorporated into a Robotics class, this could answer questions that others have pondered, e.g., How can a Multicultural Science class be implemented into a science curriculum? What effects are present with the use of a Multicultural Science program in a public school? “[The use of case studies] in transformative research and evaluation is critical because they allow for the type of relationships to develop that are needed for systematic collection of data for the purpose of social transformation” (Mertens, 2009, p. 173).

## **Context**

**Demographics and Educational Philosophy.** Tomorrow’s Future Charter School (TFCS) is an urban K-12 school located in a large city in the southwestern part of the United States. It serves approximately 750 K-12 students, the population of which is 56% Hispanic/ Latino, 20% African-American, 20% Caucasian, 3% Asian/American, and 1% Native American.

The school site is an empty church building, renovated to meet the necessities of an educational setting. Elementary and middle school students are housed in the main building, and high school students are in an adjacent building on the same campus. Most

students meet in classrooms already in place from the original facility; however, several classes meet in large rooms divided by partitions that are approximately six feet in height.

As a charter school, the teachers, administration, and governing board at TFCS are given significant autonomy (as compared to traditional public schools) for using innovative educational strategies. This autonomy, in turn, affords students the best possible opportunity for successful educational experiences. Noted below are the key elements for this charter's school instruction.

Accelerated Schools

Bilingual Education

Inclusive Education

Leadership - Leading from Behind

Literacy/Family Literacy Emphasis

Global Community

Research-based Instruction

Social Constructivism Utilizing the Tenets of Vygotsky

Education for Social Justice

Technology Enhanced Instruction

[Tomorrow's Future Charter School] will also teach its students different strategies to help make learning easier. It is our goal to help students use all that they learn in each of their school classes in real life settings. Our Global Community Program will be a place where this will happen. They will see that what they learn in class will be used in the real world as they



become working members of society. (TFCS's website, URL hidden for confidentiality)

The philosophy of TFCS has been determined by its principal, Dr. Meeks, as well as the Governing Board of ten additional adults. Being a charter school, there is more autonomy in philosophy and supporting curriculum than is typically afforded the normal public schools in its district. Therefore, Dr. Meeks has established this school emphasizing high standards in academics, which are experienced through constructivist (and social constructivist) methods of teaching and learning, as described by Lev Vygotsky. Dr. Meeks explained this educational approach as the following.

We follow the Zone of Proximal Development, first proposed by Vygotsky. Simply stated, this means that we look for the transition area of students' scholastic abilities as independent learners versus where they need help from their instructors. Teachers at TFCS receive frequent professional development for this model of instruction, so they may use it effectively in their classrooms. (Administrative Interview [AI], 3-10-12)

It allows for proximal mentoring and for students to move forward at their own pace in the areas where they have interest and can begin to hands-on explore the concepts being taught. The Global Community Program plays a major role in this philosophical mindset. Our school's motto is "Educating for Life." The goal for the Global Community Program is to educate students to prepare for interactions with projects and activities that will be skills that are job related after graduation. It focuses on incorporating academic subjects with real life experiences utilizing community partners and resources. (AI, 3-10-12)

The administrators, teachers, and governing board have put in place a unique course of study, the Global Community Program. Students within prescribed grade bands (e.g., first through third grades) attend “electives” taught by different faculty during the last hour of each school day. For the purpose of this research, the Robotics program, which was designed for fifth through eighth graders, was the particular elective under investigation. Through guided instruction and cooperative learning, students built robotic vehicles, as well as designed computer programs for the control of the vehicles. Approximately 20-25 students, who are “typically full of curiosity and excited about the program” (Dr. Meeks, TFCS Principal) participated in this class each semester of the school year. This particular program did fit within the design parameters of a Multicultural Science program, because it incorporated cooperative grouping, language development, and student autonomy within the culturally diverse setting.

The Global Community Program was conducted during the last 45 minutes of each school day, at which time all students reported to an elective class. Examples of these classes included Skateboarding, Drawing, Photography, Marine Biology, Choir, Architecture, and Robotics. These elective classes were multi-aged, grouped together as grades K-2, 3-4, 5-8, 9-10, and 11-12. Students may select a different class each semester or choose to stay in the same class for the second semester in a school year. For the purposes of this research, I observed and interacted with the Robotics class, designed for grades five through eight.

**The Robotics Class.** The instructor of the Robotics class, Mr. Norwood, has engaged in constructivist methods of teaching for the past seven years. This was his fourth year teaching the Robotics class, although his regular teaching assignment was

sixth grade mathematics at TFCS. Of the 30 students in the Robotics class during the first semester, 23 were Hispanic, 5 Black, and 2 White. Additionally, 25 of the students in the Robotics class were boys. The second semester had 25 students—4 Black, 3 White, and 18 Hispanic. Again, there were more boys enrolled during the second semester—19. Five students repeated this elective from the first semester.

As previously mentioned, some of the classrooms at TFCS are shared by several classes, divided by partitions approximately six feet in height. The Robotics class is one of these classes—gathering at the “stage” part of old church auditorium. Three additional classes meet in the same auditorium area. Although space is at a premium, his arrangement of student groupings gave me the first hint of his constructivist methods of teaching.

The countertops are approximately three feet tall and available for trial runs of the students’ small robotic vehicles. There are groupings of desks for teams of students to collaborate, as well as individual desks for students who choose to work alone. The display table is used for the execution of the tasks that Mr. Norwood has determined—ten tasks which progress in difficulty. Two student computers are available for students to develop the programs for each of the tasks their robotic vehicles must perform.

Although the robotic vehicle parts are commercially manufactured LEGO® MINDSTORMS®, the vehicles themselves are entirely constructed by the students, i.e., there are no pre-set foundations that simply need to be supplied with a few parts. Students construct each robotic vehicle, considering important functional criteria—such as the types of sensors best for a task, the vehicle’s design, wheel alignments, any necessary tools that need to be included on-board the vehicle, and its range of motion.

Using the MINDSTORMS NXT® Software installed on the computers, the student teams programmed the actions of their vehicle into the power supply of their robotic vehicle. Distance measurements, specific turns, and all tools associated with the robotic tasks had to be programmed to perfection with the robotic vehicle, because students were not allowed to correct miscued vehicle actions during the task operation. Of course, any miscalculations were noted by the students and reprogramming of the vehicle was allowed.

During the first semester, Mr. Norwood had 10 specific tasks for all of the teams to complete with their robotic vehicles. However, the second semester class was based on individual interests with robotics, and random tasks were suggested by the instructor for student teams. This was true for the whole class, including the beginning students. He meant for students who were repeating the class to be mentors for the beginning students, teaching them the basics of robotic construction. However, this did not develop, which is discussed in Chapter 5.

**Participants.** During the first semester, 25 fifth through eighth grade students participated in the Robotics class; the second semester participants numbered 20. All students were new to the class during the fall semester; however, five students elected to repeat the class during the second semester. Additionally, students came to the class with varying amount of experience in operating computerized toy vehicles. The students were of diverse ethnicities and cultural experiences, which characterized this Transformative Multicultural Science program. Their role in this research was to demonstrate and explain how they learn science, specifically in the Robotics class.

The instructor in the class also participated in this research. Mr. Norwood is a 28 year old white male, who has been involved in constructivist-oriented science education for the past seven years. This year marked his fourth year at TFCS teaching the Robotics class. Mr. Norwood's role in this study was to demonstrate and explain the instructional strategies utilized with multiage and multicultural students in the Robotics class.

Dr. Meeks, a white woman 42 years of age, is the principal of TFCS. Her involvement in the study was to provide the history and scope of the Global Community program, specifically the Robotics class. Furthermore, her expectations of the Robotics class and its instructor are described in her interviews.

### **Data Collection**

During the second day of class, a description of the research was explained to the students. Recruitment letters, student assent forms, and family consent forms were sent home at this time (Appendices A, B, C, D, and E). Furthermore, an evening meeting was offered at the school, so that all parents/guardians had the opportunity for a face-to-face description of the research. Students and their parents were informed that questions regarding any part of this research were welcomed at any time during the semesters.

Surveys, observations, and interviews were conducted with all student participants in the class, in order to determine the effectiveness of multicultural education strategies in student involvement, understanding of content, and attitudes toward this discipline. A student science attitude survey (Siegel & Ranney, 2003) was administered to all students in the Robotics class at the beginning and ending of the semester (Appendix F). All students participated in the surveys, although only the surveys from consenting participants were used in the data analysis and this report—25 students for the

first semester and 20 students for the second semester. Each participating student's survey was numerically coded and the name removed to protect his/her identity. The sole copy of student names and assigned numbers were kept with me, the principal investigator. Given prior to the first and second interviews with each of the students, this survey, based on a 5-point Likert Scale, gave valuable insights of the posture toward science that each participant carries.

Data collection also included interviews with the participating students, the Robotics class instructor, and the school's administrator (see Appendices G, H, I, and J for interview questions). At the beginning of the semester, the questions for the interviews were largely based on the results of the attitude survey, as previously stated, and the participants' initial expectations of the program. At the close of the semester, student participants were interviewed after the post survey, with regard to how the Robotics program affected their self-worth, science attitudes, science knowledge, sense of community, and relationships among diverse participants. Most interviews were audio taped. To give the student additional comfort, an instructor, administrator, and/or parent were present with the student during the interviewing process.

Marshall and Rossman (2010) describe the appropriate process of interviewing children. "This is especially true in education where those most affected by policy and programmatic decisions—the students—are absent from inquiry" (p. 115). Important considerations to this method should be noted.

1. The role of the adult interviewing a child could take on many appearances.

According to Marshall and Rossman (2010), the role of 'friend' would be the most conducive for children, since their comfort level would be better.

2. The age group could make a difference in the openness a student feels during the interview. Perhaps the middle school age student would feel more comfortable being interviewed individually or in a small group setting. It is up to the researcher to determine the comfort level of each student for the interviewing process, so that more accurate pictures to the responses are revealed.

Specifically addressing this second point, focus groups of four to five students were also interviewed. These focus groups were conducted much like the individual interviews, but with children who seem to be reluctant to share thoughts during an individual interview. The focus group interviews were conducted during regular school time only once during the semester. (See Appendix K for focus group interview questions.)

Completing the multi-dimensional collection of data (Creswell & Plano Clark, 2010), were direct observations of the Robotics classes. Approximately three to four visits to the Robotics class per week throughout the semester were conducted. During these visits, I made observations of the teaching and learning styles of the participants, their interactions/attitudes with each other and the curriculum, and specific successes/failures in working within a multicultural science setting. Descriptive field notes, as suggested by Bogdan and Biklen (2003), were collected by recording the following.

- Portraits of the subjects—Dress, mannerisms, anything that sets them apart
- Dialogue—Record what subjects are saying to each other as well as to the researcher

- Physical Setting—Furniture arrangements, posters, pictures, information on the board
- Particular events—Who was involved and what was the nature of the action
- Observer's behavior—How are the participants' viewing the researcher's behavior. (Bogdan & Biklen, 2003, pp. 112-113)

Furthermore, Bogden and Biklen (2003) describe reflective field notes, which were also used with this study. Some of the salient points are as follows.

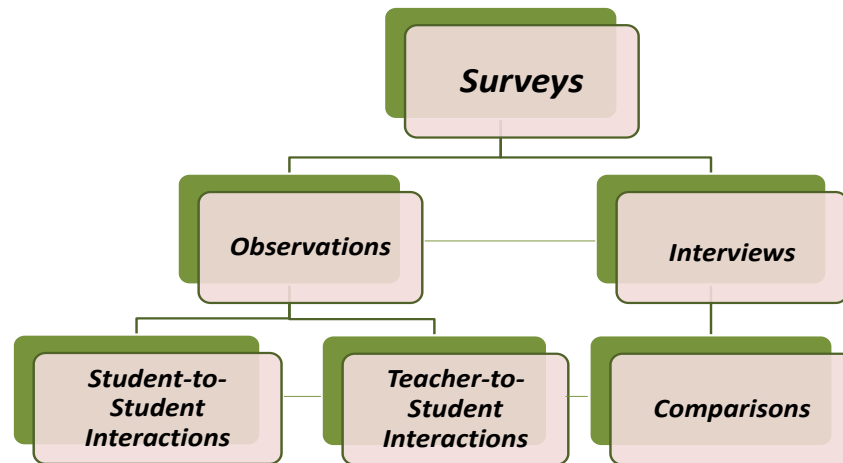
- Reflection on analysis—What is the observer learning? What themes and patterns are emerging?
- Reflections on method—Procedures and strategies are recorded here, as well as decisions being made about the study's design. Reflecting on these will help clarify any problems that arise with the methodology of the research.
- Reflections on ethical dilemmas and conflicts—The research is dealing with students and their teachers, and care should be taken to respect privacy and guard against any inappropriate comments.
- Reflections on the observer's frame of mind—Be careful to admit to oneself and be aware of preconceived assumptions and biases toward the research.
- Points of clarification—Errors can happen, e.g., names confused, dates misrepresented, etc. Record these in the field notes as they are discovered.

In summary, the following chart (Figure 3) demonstrates how the data collection connected to the objectives of this research. Each form of datum collected depended on other data as a whole. For example, the interviews were dependent upon the students' initial surveys. Furthermore, these surveys were also compared to the final surveys and



interviews, which were conducted with the students at the end of the semester.

Observations were also intertwined with the pre and post surveys and interviews of students, teachers, and administration. Such is the design of transformative research, i.e., one particular type of datum collection cannot stand alone. It is intricately connected.



2

*Figure 3:* The flow and connectivity in the design of data collection, vital to a transformative methodology.

### **Data Analysis and Representation**

Qualitative research is narrative, holistic, and naturalistic. Therefore, its data cannot be analyzed with the same procedures as quantitative research. “To analyze qualitative data, the researcher engages in the process of moving in analytic circles rather than using a fixed linear approach. One enters with data of text . . . and exits with an account or a narrative” (Creswell, 2007, p. 150). Following are descriptions of the analysis that were used for each type of datum collected.

1. Student surveys—Although surveys are often analyzed statistically, the purpose of this survey coupled with the few number of participants in this case study

means that this type of analytical procedure was not warranted. Rather, the surveys were analyzed “by-hand” using the adjusted numerical charts available from Siegel and Ranney (2003; see Appendix M). Furthermore, following the suggestions offered by Creswell (2007), the “use of categorical aggregation to establish themes or patterns” (p. 156) was applied. Responses from the student surveys during the first part of the semester guided the first interview questions for the participating students (see Appendix G). The second survey was again addressed analytically, determining categories of themes or patterns. Additionally, as with the first, the second student survey drove the questions for the final student interviews. Again, the surveys were numerically coded by the participating students’ names. The numerical coding offered the opportunity to make comparisons from the beginning of the semester pertaining to the students’ perceptions about science.

2. Interviews—Individual student interviews were transcribed from audio-recordings, and only these transcriptions were used in the analysis of the interviews. Again, pseudonyms were used for all participating students. Agar (as cited by Creswell, 2007) suggests to “...read the transcripts in their entirety several times. Immerse yourself in the details, trying to get a sense of the interview as a whole before breaking it into parts” (p. 150). This process is a unique aspect of qualitative research, and is necessary for the preparation of explaining the whole research story. As described with the survey analysis, the transcriptions were divided into categories of themes or patterns (Creswell, 2007; Saldaña, 2009) and subsequently compared to the survey themes or patterns. This

procedure helped to determine if the interview data related the same story as the surveys, which also contributed to the validity of the research. Rich, relevant narratives were identified that address the questions of this research.

3. Student focus groups—Focus groups consisted of four to five students, who exhibited hesitation at being interviewed individually. Most focus groups' conversations were audio-recorded, then transcribed and analyzed using the same methods as the individual interviews.
4. Interviews with the teachers, administrators, and parents/guardians were transcribed and analyzed using an approach Creswell (2007) calls *direct interpretation*.

In direct interpretation, the case study researcher looks at a single instance and draws meaning from it without looking for multiple instances. It is a process of pulling the data apart and putting them back together in more meaningful ways. (Creswell, 2007. p. 163)

5. The second survey was analyzed in the same way as the first survey. The numerical codes were matched with the first survey to identify any change in students' attitudes or perceptions toward science.
6. The second individual interview conducted with the students was guided by the survey answers and the matching numerical coding. For example, imagine that Susie, #707, exhibited some negative efficacy toward her performance and attitudes in science her answers on the first survey. In reviewing the second survey, #707 showed a more positive self-image toward the subject. Interview

questions were then formed for Susie (#707) based on her passage into her more positive feelings.

7. Throughout the research process, interviews and observations (along with field notes) were examined using “inductive analysis where the salient categories emerge from the data” (Patton, as cited by Marshall & Rossman, 1999, p. 154). Constantly reviewing the themes and categories throughout the research is critical in case study analysis. “It is a research design for multi-data sources, which is like analytic induction in that the formal analysis begins early in the study and is nearly completed by the end of data collection” (Bogdan & Biklen, 2003, p. 66). By continuing to review the data as they were collected, the study continued to grow in depth and richness and, subsequently, contributed to more naturalistic interpretations (Saldaña, 2009).

Finally, the writing of the report includes all the accounts, stories, themes, and voices of the participants. Several figures have been used in this report, but the most powerful component of reporting a case study is in telling the story—describing in narrative what has been learned and what is still yet to be discovered. Naturalistic generalizations are formed from the data—“generalizations that people can learn from the case either for themselves or to apply to a population of cases” (Creswell, 2008, p. 163). However, this does not mean that a case study is generalizable. Because of this, some qualitative researchers prefer to use the word “transferability” (Lincoln & Guba, 1985; Mertens, 2009) in examining the reliability of a case study. “Transferability refers to the ability of the researcher/evaluator to present the findings to readers so that they can assess the [accessibility] of the results of one study to another situation” (p. 195). It is the

reader's (as opposed to the researcher's) interpretation of the data analysis and reported results that makes the study transferable to another situation that is known by that reader.

## Timeline

The timeline for this study is illustrated in Figure 4. The original timeline had to be adjusted due to constraints with the school's schedule, as well as the reluctance of the some students to participate in the research. (This reluctance is discussed in the final chapter of this report.) Additionally, the writing of the final draft was a continual process throughout data collection and analysis (Bogdan & Biklen, 2003; Saldaña, 2009).

Month	Surveys	Class Observations	Student Interviews	Other Interviews	Transcribing Data	Analysis	Writing
Sept.	S-1	X	S-1	T	X		
Oct.		X	S-1	A	X		
Nov.		X	S-2	F	X	X	X
Dec.	S-2	X	S-2		X	X	X
Jan.	S-1	X		T	X	X	X
Feb.		X	S-1	F	X	X	X
March		X			X	X	X
April	S-2		S-2	F	X	X	X
May						X	X

Key: S=Students; T=Teachers; F=Focus Groups; 1=Fall Semester; 2=Spring Semester; X=Occurred at this time

*Figure 4:* Timeline for conducting Robotics Class research for 2011-2012. Notice that analysis and writing began soon after data were collected throughout the semesters.

## **Bias and Reliability**

I came to this study with some bias; I am a proponent of multicultural science education and social constructivism. I feel that it may be the answer to connecting all students to science education. Acknowledging this, I was open with my data collection, soliciting reviews from my peers as the study advanced. Furthermore, all participants (including the parents/guardians of the student participants) were given the opportunity to read the completed research report.

In order to establish validity for the results of this research, I followed the suggestions of Lincoln and Guba (as reported by Mertens, 2009). I have included my rationale (using this particular case study of the Robotics class) with the descriptions reported by Mertens.

1. Internal validity/trustworthiness—Persistent observations involving staying with the study a prolonged amount of time. Since data from this particular case study were collected over two semesters (fall and spring), internal validity was established. Data included weekly classroom observations.
2. Peer debriefing—Having a “disinterested” party as part of the research review process prior to the research being reported. Several of my teaching colleagues were eager to be my peer reviewers. Of course, my dissertation committee members worked with me throughout the research process.
3. Progressive subjectivity—Continuous reflection by the researcher. Since I transcribed and analyzed the data as it became available, I was able to continually identify themes within the data and examine their relationships.

4. Member checks—Checking the believability of the data with others familiar with the participants. The administrator and teachers involved with this research consistently assured me that data I collected were consistent with prior observations of the Robotics class.
5. External validity/transferability—The readers' interpretation of one research relating to another situation. This research built upon Powell's (1996) research concerning culturally relevant teaching, as well as research related to instructional congruence, social constructivism, transformative curricula, Multicultural Science, and transformative research.
6. Reliability—The research would produce the same (or close to the same) results upon a second evaluation. Although it is hard to guarantee the same results with another case study evaluation, I worked closely with the staff of TFCS, who have been involved with the Robotics class prior to this research. They have been able to confirm the reliability of the findings after reading the entire research report. However, as suggested by Creswell (2009) and Merriam (2009), qualitative research, e.g., a case study, is designed to add to the literature for a particular concept, framework, or paradigm.
7. Confirmability/Objectivity—Being able to interpret and report research results without bias. As stated, I came to this research with bias in favor of Multicultural Science programs. However, with the data being open to examination by my participants as well as my committee members as it progressed, I am confident that any bias was minimal.

8. Authenticity—A fair and balanced view of the research is presented, and “community members are able to use the information for the furtherance of social justice and human rights” (Mertens, 2009, p. 196). The participants and their families had the opportunity to read a draft of the study prior to its final presentation to my doctoral committee.

## **Conclusion**

In Chapters 1-3 of this study, I outlined the need for this case study, as well as the research literature that lent support to this need. Literature is abundant with theoretical papers proposing Multicultural Science in classrooms. However, most (if not all) research conducted in this area deal with Indigenous populations and/or tribal schools. A gap in the literature exists due to a lack of empirical studies conducted in public schools concerning Multicultural Science.

The methodology for data collection and analysis that were conducted during the two semesters of the Robotics class were outlined. An instrumental case study (Stake, 1995) was determined to be the best approach since it examines a particular phenomenon in order to answer a unique question that other researchers have also pondered.

In the following chapter, the results of this study are discussed. Identified themes and categories, as well as their supporting data, are revealed through the voices of the participants.



## CHAPTER 4

### RESEARCH RESULTS

Data collected during the two semesters of the Robotics class at Tomorrow's Future Charter School (TFCS) included pre and post science attitude surveys, individual interviews, focus group interviews, and classroom observations. While collecting, categorizing, and analyzing the data, three categories became apparent—the students' perceptions of science and of being a scientist, the strong (yet delicate) nature of student autonomy, and the students' responses to the instructor's constructivist pedagogy. The following section will describe these categories, substantiated by the narratives from the students, their instructor, and the principal of TFCS. Prior to reviewing these categories, a description of the school and its philosophy will be given, as well as a detailed account of the Robotics class and how the instructional strategies that are utilized in the class align with the characteristics of Multicultural Science.

#### **Instructional Strategies**

In order to determine the validity of the Robotics Class being classified as an example of a working Multicultural Science paradigm, I observed specific instructional strategies utilized by the instructor. I also observed how Mr. Norwood addressed the Nature of Science (NOS) with his students, i.e., if he explicitly addressed its components as the NOS. The following sections highlight various instructional strategies conducted by Mr. Norwood and their correlation to the ones that define Multicultural Science, as outlined in Chapter 1 of this report.

**Instructor's introduction to the robotics class.** During the first class meeting, Mr. Norwood had students sitting on the floor around the Teacher Projection area in the

classroom (see classroom map). As he sat on a chair in the midst of the students, he presented a PowerPoint which explained how robotics are used in our world today, the importance of robotics in the future, and how robotics may be important to them personally. Throughout the presentation, Mr. Norwood offered questions and provided time for several discussions among the students concerning their experiences with any robotic mechanisms and how they perceive robotic usefulness in our world (Personal Field Notes [PFN], 1-20-12). I later commented to Mr. Norwood that I was impressed with the discourse he prompted with his students. His response was, “Well, that’s a key to good teaching—having good conversations with the students” (PFN, 1-20-12). Certainly, this discourse with students is a secondary component, if you will, of the Nature of Science; however, Mr. Norwood never addressed his students that questioning and discourse among each other has anything to do with the creativity of science, one of the components of the NOS. It appeared that he was leaning toward a more intrinsic model for teaching the NOS.

During Mr. Norwood’s initial Robotics Class PowerPoint presentation, he outlined the relevance of robotics in our global society, including NASA’s robotic vehicles that are now on Mars; mathematically programming Stardust, an eight year NASA mission to collect a comet’s particles; and, closer to home, remote-controlled equipment that enhances our standard of living. This is the heart of a Multicultural Science program, giving students the opportunity to design, explore, and discover the connections between the science and their lives. As students learn to work with a team and listen to each other’s ideas, they gain life-skills necessary for their future.

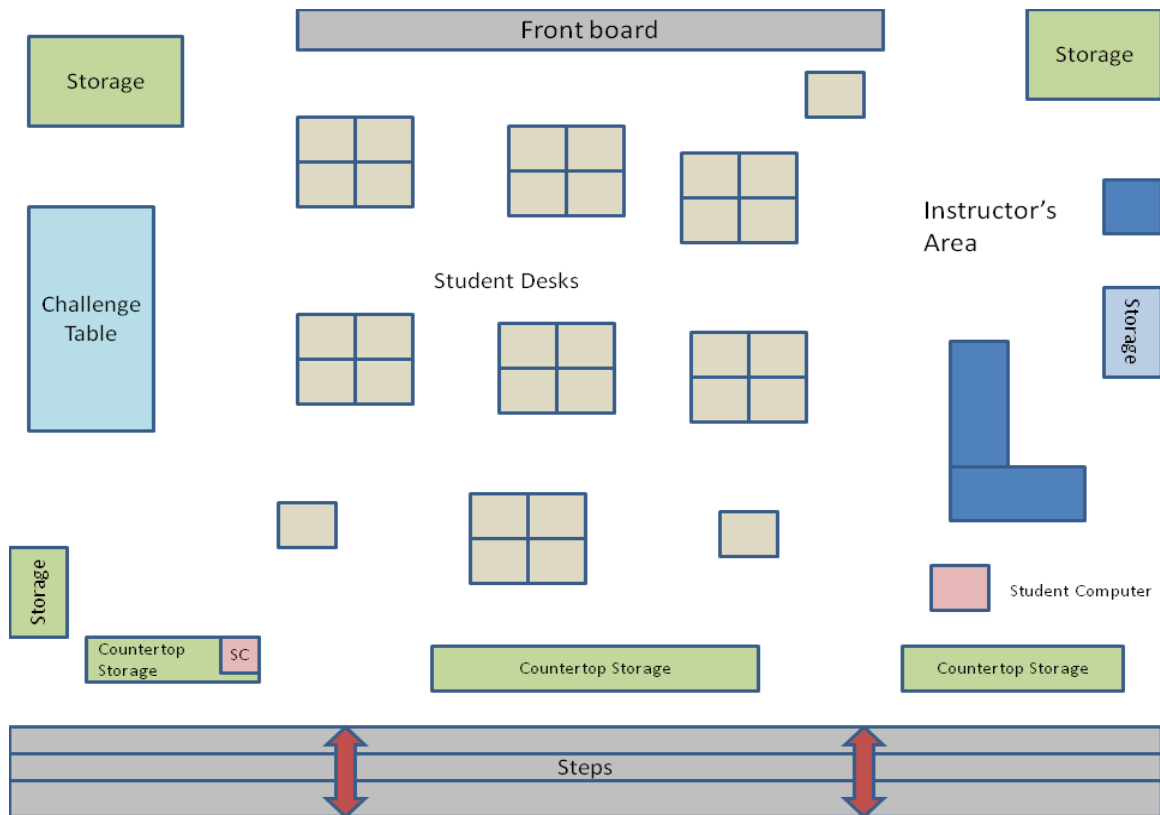
This initial introductory lesson correlated with Multicultural Science characteristics in several ways. First of all, by having students sitting in a group on the floor with him in their midst, Mr. Norwood subtly demonstrated to his students that he valued their autonomy in the class. As was previously mentioned, Multicultural Science acknowledges students and their instructor as fellow learners. The teacher is not the fountain of knowledge; students and teachers work together to construct knowledge (Atwater, 1995; Bryant, 1996; Doll, 1993; Gergen, 1991).

Secondly, as Mr. Norwood presented the PowerPoint, he elicited student discourse, which is also a feature of Multicultural Science learning strategies. “Teachers would invite students into modes of dialogue as participants rather than pawns, as collaborative interlocutors instead of slates to be filled” (Gergen, 1991, p. 250). These discussions were not just between the instructor and one student; but rather, Mr. Norwood orchestrated discourse from students to other students.

Finally, discussions were also conducted concerning how robotics could be relevant to the students’ and their families’ future. This component of Multicultural Science has been routinely emphasized by researches. All science is relevant to the student, the family, the classroom, the school, the community, the world, and the universe (Aikenhead, 1996; Barba, 1998; Cajete, 1999; Fixico, 2003).

**Configuration of the robotics classroom.** The Robotics classroom was conducive to Multicultural Science instructional strategies. This was evident because student groups have areas to gather for planning; individual seats are available for students working on specific tasks or for those who have chosen to work alone; student

computers are available for robotic programming; and an open storage area containing robotic parts is accessible to all students, as shown in Figure 5.



*Figure 5:* The arrangement of the Robotics classroom, which illustrates teaming opportunities for students, as well as student autonomy.

The classroom arrangements encouraged a socially constructive approach to learning science, a key component of Multicultural Science instructional strategies. Mr. Norwood's classroom promoted peer tutoring, provided for the use of home language in small groups, encouraged students to work cooperatively in constructing new knowledge, and permitted students to interact with manipulative materials (Cajete, 1999; Gaskell, 2003; Lee, 2003).

**Student inquiry and discovery.** Components of Multicultural Science instructional strategies were evidenced in the Robotics classroom,. Mr. Norwood insisted

that students try to solve problems on their own (or within their groups) before he offered assistance. On one occasion, a student brought a problem to Mr. Norwood, asking him for a solution. His response was, “Have you tried to solve this on your own yet? I do not see any evidence that you have tried to work this out. Do that first. You learn things better if you figure them out on your own.” The student smiled, returned to her table, and worked on the problem. Approximately ten minutes later, she discovered the solution (PFN, 4/12/12). Student discovery and inquiry are elements of what Doll (1993) refers to as student internal intervention, which is the goal of the transformative, Multicultural Science classroom.

**Student autonomy and rigor.** Mr. Norwood expected teamwork, communication, equality, respect for peers, and responsibility in caring for the robotic equipment. He also expected each student to identify themselves as real-life engineers. For example, after students had worked on one robotic vehicle for a couple of weeks, Mr. Norwood announced that they were to take the vehicle apart, return all the pieces to the supply cabinet, and begin again with designing another vehicle. He explained to the students that real engineers may take apart their projects several times to correct small mistakes or discover more efficient ways to construct their project (PFN, 10/13/11). This exercise correlates with the characteristic of rigor, as defined by Doll (1993). “One must continually be exploring, looking for new combinations, interpretations, patterns...different alternatives, relations, connections” (p. 182).

**Authentic assessment.** Multicultural Science instructional strategies include authentic assessment (Calabrese Barton, 2003; Hines, 2005). The ultimate test or assessment in Mr. Norwood’s Robotics Class was the successful completion of robotic

tasks/challenges. Students in this Robotics Class were anxious to meet the challenges and tasks presented by Mr. Norwood, unlike typical exams (e.g., multiple choice) experienced in traditional, modernist classrooms.

Additionally, I interviewed Mr. Norwood concerning the instructional strategies that are used with his diverse population of students in the Robotics class. He referred to the socially constructive educational atmosphere in the classroom as “student-directed learning.” The following dialogue is an excerpt of Mr. Norwood’s description of his instructional strategies.

Researcher (R): What strategies have you incorporated in this Robotics class to ensure that your culturally diverse students feel connected and motivated to work with this [Robotics] curriculum?

Norwood: First of all, student-directed learning is less dependent on language and cultural connections perceived by the teacher. Students work that out on their own. Secondly, small group learning also allows students to construct their own models and concepts. There are natural leaders in each group; however, they learn to listen to one another’s ideas for the design and construction of the vehicle. Third, math is a universal language. As the students work on their designs and work out the dimensions needed for their vehicle, math is the language used among members of the group. Finally, the students do not need a teacher to tell them when they have succeeded – the robot tells them, by successfully accomplishing the job.

R: What successes have you experienced in this class?

Norwood: Many students, even those who have trouble demonstrating mastery of skills through traditional assessments, have been able to design, build, and program sophisticated robots that can execute multiple step algorithms, including programming tools and the use of sensor data to create interactivity. This kind of learning is generally unlike other parts of their school learning (Teacher Interview [TI], 11-15-11).

The components of Multicultural Science, as revealed through the academic research described in Chapter 1 of this report, have been compared to my observations of the instructional strategies exhibited in the Robotics class. Furthermore, Mr. Norwood's description of "student directed learning" parallels the social constructivist paradigm of learning. I concluded from this comparison that Mr. Norwood has been utilizing Multicultural Science instructional strategies in his Robotics Class. Additionally, these instructional strategies aligned with Powell's (1997) work on constructional congruence, as outlined in Chapter 2. Therefore, I continued to make classroom observations and conduct interviews to obtain a better understanding of the students' responses and reactions to this type of pedagogy.

The next sections of this chapter describe findings from the questionnaires, observations, and interviews with students in the Robotics class. Following the results of the students' questionnaires, findings from interviews and observations are presented.

### **Student Survey Results**

The Student Science Attitude Survey, as outlined by Siegel and Ranney (2003), was administered to the Robotics students at the beginning and end of the fall and spring semesters. (The survey was not given to students repeating the Robotics class during the

second semester). Students' responses were recorded using a Likert scale, numerically scored from five to one, five being "strongly agree" and one being "strongly disagree." I scored the student surveys by hand, as the number of participants was low for both semesters of the Robotics class. The initial categories and the equivalent scores for each response, as outlined by Siegel and Ranney, included the following:

1. Finding science strongly positive in students' lives (5points),
2. Finding science positive in students' lives (4),
3. Finding science neutral in students' lives (3)
4. Finding science negative in students' lives (2), and
5. Finding science strongly negative in students' lives (1).

Scores were tallied for each student, and (from these scores) four new summation categories were described. The surveys were used solely to drive the questions for the individual and focus group student interviews. Listed below are the summation categories and their descriptive criteria, again as outlined by Siegel and Ranney (2003). The first two categories are more positive responses and the last two are more negative responses.

1. VSR – Student very strongly believes that science is relevant to life.
2. RM – Student believes that science is relevant to most areas of life.
3. SR – Student believes that science is sometimes relevant to life.
4. SI – Student strongly believes that science is irrelevant to life.

A more in-depth description of each category may be found in Appendix L.

From these data—surveys, individual interviews, focus group interviews, and observational field notes—I identified three main categories, all of which are discussed in the following section. Descriptive coding (Saldaña, 2009; Wolcott, 1994) was used to



identify these categories. This type of coding is “appropriate for beginning qualitative researchers learning how to code data...[on] studies with a wide variety of data forms” (Saldaña, 2009, p. 70). As I constantly reviewed the data (field notes, surveys, and interviews), I noted the topics that were disclosed, and then subsequently classified these topics into main categories.

### **Identification of Categories**

Data were gathered using 17 individual student interviews, 5 focus group interviews, and 32 classroom observations during the two semesters of the Robotics class. As the interviews were transcribed and classroom observations were written, three main categories were identified—the influence of students’ perceptions of science toward their view of scientists (and vice-versa), the strong (yet delicate) nature of student autonomy as it relates to students’ personal science efficacy, and the students’ responses to the instructor’s constructivist pedagogy.

**Students’ perceptions of science and of being a scientist.** Two of the closely related topics addressed in the Student Science Attitude Survey were students’ perceptions of the meaning of science, and its connection with students’ perceptions of being a scientist. As these topics elicited strong responses from several students, I decided to make them a focal point with those students’ individual interviews. For example, one of the questions reads, “Science class helps me to judge other people’s points of view.” A student scoring of *agree* or *strongly agree* is considered to be a positive response. However, when *strongly disagree* or *disagree* was chosen, I decided to address this in the individual’s interview. This particular statement tells the researcher about the respondent’s attitude toward science as it connects to other areas in life, in this

case being able to listen to other's points of view. Following is an excerpt from an interview with Juan, a fifth grade Hispanic male student, concerning this topic.

Researcher: Juan (pseudonym), I noticed that you strongly disagreed with the survey question which stated that science class can help you judge other people's points of view. Will you explain to me why you believe this?

Juan: I don't know. I don't think I knew what it was talking about. I've never heard that before.

R: What haven't you heard before?

Juan: Points of view?

R: Well, it means that sometimes you may disagree with someone on your team in Robotics, and that in science you have learned how to step back a little and think about if their ideas could be good ones.

Juan: Oh...(long pause) I guess so but maybe not just because of science or Robotics class. I mean my mom tells me that too when I am fighting with my brother.

R: Do you think then that this could be something that's learned in science or Robotics, say with other students?

Juan: Yeah I guess so.

R: How could that be learned or practiced in Robotics?

Juan: Well, we have to work together for the team challenges and making the car in the first place. If we all had to have everything our own way, we wouldn't be finished with our car in time to do the challenges. And, when

we do argue, Mr. Norwood makes us break apart until we think we can be nice and listen to each other.

R: So, do you think that this is part of what science is? Because I noticed that on the survey you agreed that on the survey you agreed that science will help you understand more about world-wide problems.

Juan: I guess so. I don't know... I always thought science was about the world and studying the things in the world... not about if I can agree with someone or not. I thought that was about being nice or mean. (Juan Interview, 10-15-11)

Juan did not understand the language of the survey, and yet he did not choose to mark a more neutral response; rather, he marked the extreme value of *strongly disagree*, regardless of its connotation. Also, as I reviewed and reflected on this survey question, I concluded that the understanding of the Nature of Science (NOS) was this question's focal point. Clearly, Juan did not understand this, as he had no connection between *science* and *understanding another person's point of view*, which is a component of the NOS. These results align with the research done by Allen & Crawley (1998), as reported in Chapter 2 of this study, in which Native and Euro-Centric views of the Nature of Science were compared.

Another student's responses mirrored Juan's. Following is a part of the interview with Julian, a male Hispanic seventh grade student. I asked him about a different question on the science attitude survey, which also addressed the connection of science to humans' daily lives.

R: (about 10 minutes into interview) Julian, I see on your survey that you strongly disagreed with the statement that “Knowledge of science helps me to prevent the spread of colds/diseases.” Can you tell me your thoughts on that?

Julian: Like an astronaut. How could learning about rockets help someone know about a disease? Or a rock guy, you know the guys that go hunting for fossils and diamonds? They can get a cold or the flu. What does knowing fossils and rocks have to do with a cold? Doctors and nurses know that stuff. (Julian Interview, 10-20-11)

Juan and Julian have definite beliefs about the components of science as well as what it means to be a scientist. While Juan did not understand how science and active listening to other’s ideas could be connected, Julian had further misconceptions about being a scientist. He categorized scientists as having knowledge specific only to their disciplines, e.g., astronaut, geologist, and those in the medical field. Again, these misconceptions are related to the lack of understanding toward science in a broad sense, i.e., the NOS. This lack of understanding about scientific connections appeared to have influenced the misconceptions toward being a scientist.

The following narrative is from an interview with Maria, a sixth grade Hispanic female. I observed her to be very reserved in class, as well as in the interview. However, after Maria became more comfortable with our discussion, she freely expressed her ideas concerning the meaning of science, along with a hint of how she perceived scientists.

R: Hi, Maria. I have a couple of things I’d like to ask you about your Robotics class and science.

Maria: OK. Are they hard questions?

R: No, nothing like that. There are no wrong answers here. I just want to know your opinion, that's all.

Maria: (nods her head, with no smile)

R: Do you remember the questions on the blue sheet that you answered last week? Remember now, there were no right or wrong answers on this survey either. I am just curious about a statement that you really disagreed with, "Science helps me work with others to find answers." Can you explain to me why you disagree with that?

Maria: Umm. (hesitation) Was I wrong?

R: No, not at all. I just want to hear from you why you disagree with it.

Maria: Well, I know we have to work together in science class and here in Robotics, too. But, I thought we are working together to find the answers from the science book or how the robot car works. I didn't think that working together is part of what science is. Reading class—we have groups there too and we read books together. That's not science (chuckle). Oh in math we sometimes do things in groups—like teams for a contest or something. That's not science, that's math.

R: Well, what is science, Maria?

Maria: Well, I don't know if I can describe it. It's when you study about something that has to do with the Earth like bugs, or animals, or plants, or potions that bubble, or planets and stars, or tornados and clouds. Things like that.

R: Is Robotics class science?

Maria: No! (emphatically) Mr. Norwood says that Robotics is engineering.

R: Is engineering part of science?

Maria: No. Engineering you build stuff, science you discover stuff.

R: Is Mr. Norwood a scientist?

Maria: No! (laughs) He is an engineer! And, he teaches math here [TFCS], not science.

R: Can you think of someone who is a scientist?

Maria: Einstein! He has crazy hair! (Maria Interview, 2-1-12)

Clearly Maria's perceptions of science did not include socially constructed learning. She viewed it as a strategy used in her reading and math classes, which she definitely separated from science. Reading and math were not part of her understanding of science. Furthermore, she gave a hint as to how she stereotypically perceived scientists with her description of Einstein's wild hair.

Philip, an eighth grade White male, described further how one's perception of scientists, e.g., crazy hair, can permeate one's attitudes toward science.

R: (five minutes into the interview) What is a scientist?

Philip: It a dorky man that likes to be alone to investigate stuff.

R: Oh like on CSI, detectives trying to solve a crime?

Philip: Well, the lab people, but the others are police.

R: You said man; can a woman be a scientist too?

Philip: I guess, but more men are scientists. That's why I'm lucky.

R: How's that?

Philip: I'm a boy and I can be a scientist if I want to. Not a dorky one though.

R: What do you mean?

Philip: I wouldn't have wild hair that sticks out everywhere and I would keep pens and pencils in my desk or notebook, not in a pocket. (laughter)

R: Is Mr. Norwood a scientist?

Philip: NO! (emphatically) Look at him. Does he look like a scientist? Besides he teaches math, not science. (Philip Interview, 2-3-12)

Again, Philip had definite ideas about who can be scientists, as well as their appearance. Certainly, this stereotyped misconception continues to influence students' ideas concerning the meaning of science. However, toward the end of the semester, these students—Juan, Julian, Maria, and Philip—demonstrated subtle changes in their personal meanings of science and about being/becoming a scientist. Noted below are comments from individual interviews with these students within the final two weeks of their semester with Robotics class. I read their previous interviews to them prior to asking the new question. These portions highlight the students' new thoughts as they are compared to their previous interviews.

R: Tell me what you have learned in Robotics class this semester about your understanding of what science and being a scientist are all about?

Juan: Well, I did notice that we had to listen to each other's ideas when we were trying to make our robot do the challenges. One person in our group wanted to do it all himself and he got mad and went to do one [a robot] on his own. At first we were glad he left. Then we really wanted him to be with us because he could do the computer stuff so good. He came back to

our team and we decided to divide the jobs with what we do the best. Like he was the computer guy, Lindsey was the equipment manager and robot designer, and Seth and I put the robot together. We did 8 of the 10 challenges. It was so fun! I am a scientist 'cause my team figured out how to do them [the challenges]. (Juan Interview, 12-10-11)

Julian: What I remember is that we had to use a lot of math, writing, and lots of thinking and talking to make things work for the challenges. That was hard for me, 'cause I thought we would just put a car together and it would be easy. But we had to write down everything we did and measure how far the robot had to go. Then we had to read directions [from the computer] and think about how to make the robot do what Mr. Norwood wanted. I bet scientists have to do that all the time. (Julian Interview, 12-13-11)

Maria: Ok. I thought about this the other day when our regular science teacher said to us that if we ever ask the question why, then we are scientists. I say that [why] all the time (laughter). So I guess that anyone who asks questions is a scientist. I asked Mr. Norwood if he is a scientist and he said 'Yes.' I said, 'but you're an engineer,' and he said that he could be a chef and still be a scientist. I guess they don't have to have wild hair, either. (Maria Interview, 4-18-12)

Philip: There were two girls on our team. At first they were really quiet, but then [the] second challenge failed, and we were all sad and mad about that. The girls started making some changes [in the robot design] that were really good. They had good ideas. I guess we were kind of like scientists. But, I



don't think we are scientists. Isn't that like a job a person has when they grow up? (Philip Interview, 5-5-12)

Clearly, there are slight changes in attitudes toward science and what it means to be a scientist with each of these students. Two of the four students (Juan and Philip) responded with the importance of cooperative teaming. They were free to have open communication; able to socially construct their understanding of robotics; unhampered in experiencing student (and team) autonomy; and active in their participation of designing, constructing, and operating their robot. Indeed, these are all components of a Multicultural Science curriculum and its classroom.

Two students had some changes in their attitudes about scientists. First, Maria came to understand that scientists are people who ask and research questions. This idea was underscored for Maria during her regular science class at TFCS. Furthermore, by acknowledging this new idea of being a scientist, Maria was able to release the stereotypical wild hair characteristic for scientists. Secondly, Philip realized that girls on his team were a positive influence. Their creative nature led to a more dynamic design of the robotic vehicle, which resulted in meeting the challenges Mr. Norwood had made for them. However, Philip still struggled with the term *scientist*, as he held onto the notion that *being a scientist* was a career or job.

**Connection between student autonomy and student efficacy.** The second category that became evident from the data was the strong connection between student autonomy and student efficacy. As students worked in their groups during the semester, I observed their confidence growing with their Robotics projects. This self-efficacy was

directly related to the autonomy they experienced both as teams and individuals.

Following are some of my personal field notes that reflect these observations.

This was the first day of the semester -- Mr. Norwood gave his presentation about the Robotics class to the students. They were all seated on the floor around his chair facing the projection screen. The students appeared to feel comfortable asking questions about the PowerPoint and Mr. Norwood encouraged discussions about the purpose, need, and usefulness of robotics historically and for the future. Very informal setting and students appeared excited about the class and building their own robotic vehicle. (PFN, 1-26-12)

Mr. Norwood used several teaching strategies that fit within the paradigm of Multicultural Science. First, as noted above, allowing students to sit closely together around his chair was the first sign of giving students their own sense of equality with him. They could immediately sense that he was their mentor, not their dictator. This perception of Mr. Norwood continued throughout the semester, which built on the students' personal autonomy. A second strategy Mr. Norwood incorporated into his teaching techniques was to encourage students to work through problems they might encounter. He did offer assistance and reassurance to the student teams as they were learning the basics of robotic construction and programming. However, he also encouraged students to rely on themselves more than him as they participated in the program. The following excerpts from my Personal Field Notes demonstrate this instructional strategy.

Mr. Norwood walked around the classroom today as students were beginning the construction of their vehicles. Several students asked him if they were

constructing things correctly, to which he replied that the ultimate test of right or wrong was not him, but the vehicle. He said that they would be able to figure it all out when they attempted a challenge. (PFN, 10-15-11)

There are not as many students questioning Mr. Norwood today. Students are working within their teams pretty efficiently. The first two challenges are ready, so I wonder how long it will be before students can master them. When Mr. Norwood explained the first two challenges today, I noticed that team members were looking at each other with less than confident facial expressions. As I visited the teams, I asked how they thought their robotic vehicles would meet the challenges. For the most part, students were nervous about adjusting their vehicle to do the challenges, but they were all anxious to give them a try. (PFN, 10-18-11)

A large table was set up in the classroom for student teams to attempt the 10 robotic challenges. Just before the school's October holiday break, one of the teams accepted the first challenge—to program their vehicle to move down a designated course (with turns), pick up a payload of small cubes, transport them back to the original starting point, and then deposit them in a container. When the first team met this challenge, there was excitement in the air!

“We did it! We did it!” The first student team to meet a challenge chanted this over and over today as they danced around the classroom. All the other students in the class were excited, too, and wanted to get their robotic vehicles into the challenges. This is the kind of day that makes a teacher love education. Students congratulated the team for being the first to meet a challenge, and Mr. Norwood

shook each of their hands. I don't think that the students could smile any bigger than they were today. (PFN, 10-22-11)

Of interest to me was the growth in self efficacy that the students exhibited as they became more creative with the diverse challenges. For example, twice during the semester Mr. Norwood came into class and announced for the students to take their robotic vehicles completely apart, returning all the parts back to the storage compartments. Each incident had different student responses, as noted in my PFN.

I was in shock today when Mr. Norwood announced to all the students that they were to take apart their robotic vehicles totally apart, filing away the parts and pieces into the storage cabinet. Students were just as shocked as I was, saying, "What? Why?" and "But our robot is ready to do a challenge today." Mr.

Norwood calmly told them that they were now engineers, and as such, they would work as engineers. Many times engineers will tear apart their work to clear out errors or look at the problem to solve in a different way. (News to me!) However, they did what he said, even though they were grumbling about it. (PFN, 11-1-11)

Although the students were not happy, and complained loudly about the reassembling of their vehicles, they did take their precious vehicles apart, because they trusted Mr. Norwood's directions. The second time Mr. Norwood surprised the class with this decision, a different response came from the students, which actually surprised me, as I noted in the following PFN.

OK, he did it again! Mr. Norwood came into class and announced that it was a day to completely take apart their vehicles and reflect on any errors in the vehicle's construction or how it could be more efficient. To my surprise, students

cheered! Several students were heard saying that they were waiting for him to say that. When I casually asked students how they felt about this announcement, most were fine with it, with a few saying enthusiastically, “Bring it on!” They were quick to tear their work apart, and start at the drawing board again. I can’t help but believe that the autonomy Mr. Norwood has given them has led to this heightened confidence in their work. (PFN, 12-1-11)

In an end-of-the-semester interview with Samuel, a Hispanic eighth grade male, he voiced the same sentiments of many Robotics class students. Following is an excerpt of Sam’s interview that addresses his autonomy in the class and how it connects with his self-efficacy in science.

R: Sam, what was your favorite thing about Robotics class this semester?

Sam: That we got to build and experiment with stuff on our own, well with our team, without a teacher telling us how to do it all. At first, I didn’t think I could do it, cause it looked too hard to build, and had to be so perfect with the centimeters and stuff. But, Mr. Norwood let us try different things and practice them on the bookcases, so we found out how the robots worked.

R: So, you don’t think that a teacher is necessary to give directions for a task or experiment?

Sam: Well, maybe not so much directions. When our team worked the problems out on our own, we knew how to fix other problems.

R: So, are you saying that since you and your team worked on your own with solving the engineering problems, you became better at solving the next problem you faced?

Sam: Yeah. Sometimes we really wanted to ask Mr. Norwood about something, and he would help us a little, then make us do the rest of it [solving the problem] by ourselves. I like that kind of teacher.(Samuel Interview, 12-12-11)

During the second semester, Mr. Norwood did not have the table of 10 challenges. He wanted a more casual semester where students created their own challenges. This was true for all students, those just beginning and those that were repeating the class; students repeating the class were mentors and guides for the new teams of students. As the semester progressed, two teams of students created their own robotic machines, as recorded in my PFN. These teams were students who were repeating the class and, subsequently, well versed in the creativity and construction of robotic mechanisms.

Today a team tested their own creative vehicles to meet their own challenges. Students in the class gathered around one of the bookcases to watch a basketball vehicle that moved to a designated line, catapulted a large cube into an elevated paper replica of a basketball goal, and returned to its original position. The robotic vehicle consistently scored in its basketball shots, which made for a lot of excitement in the classroom. Students cheered on the vehicle, as if it were an NBA basketball player. Perhaps this is the future of team sports! (PFN, 2-20-12)

Another team tested their personal challenge with their robotic machine. It was not a vehicle this time, but a pitching machine and automatic batter. It was timed out perfectly for the bat to swing one second after the pitch. The pitch was rolled and the bat was on the ground as well. Its accuracy was amazing, and the teams were very proud of it. They had followed instructions posted online about

the computer programming involved. Students were cheering on the pitch and subsequent hit with the bat with lots of laughter and talking to each other. (PFN, 2-22-12)

Just as these repeat students excelled in their robotic creations, others who were first-time students eased into an opposite path as the semester progressed. Since there were no particular challenges during the second semester, as compared to the 10 challenges from the first semester, new students became disconnected from the program, which became a sub-category of this theme. In this case, the students' autonomy and self efficacy connection became somewhat fragile in nature.

**Fragile nature of student autonomy and self-efficacy.** During the second semester of the Robotics class, students were not given particular challenges to perform with their robotic vehicles. After the initial excitement of learning how to put the robotic vehicles together and program them to do simple tasks, students became bored, which led to misbehavior in the classroom. This phenomenon took me by surprise, as I recorded in my Personal Field Notes.

I have been away from this class for a week, so I was happy to see the students again and was looking forward to seeing what new challenges they had come up with for themselves. When I came to the classroom, at least half of the class was missing—including students from the previous semester. When I asked Mr. Norwood about this, he told me that they had been sent out of this class due to poor behavior. They had been just cruising around the room, not working on any robotic device, and ignoring any new student who needed help. Also, the new students were just tinkering around with robotic car parts. I sat down with one

student, Venice, and asked her how things were going. She answered, “Pretty boring.” I asked her why she said that and she replied that she didn’t know what to do. I asked her where her team was, and she said that two kids on her team were sent out of Robotics for acting up and the other one was doing her math homework. She had taken her vehicle apart and just wanted to talk to me about things at my school. (PFN, 3-20-12)

About a week later, I was reviewing an interview with Tyland, a Black seventh grade male student, who was new to the second semester class. I became saddened by his change in attitude about the Robotics class, and consequently, about technology as a career. At the beginning of the second semester, Tyland (Ty) had chosen “strongly agree” with the survey statement, “I am interested in a career in technology, e.g., computer programming and video game building.” However, I noted that at the end of the second semester, Ty had scored “strongly disagree” with this same statement. Following is an excerpt from his interview.

R: Tyland, I noticed you changed your mind about becoming a computer programmer or video game builder from the beginning to the end of the semester. Can you tell me the reasons that you changed so drastically after having the semester with Robotics class?

Ty: Well, it was really fun at first. But my group kinda fell apart. One of our guys was sent out of Robotics for being bad, and he was the one that knew how to do everything. So the rest of us did not know what to do.

R: Did you tell Mr. Norwood about your problem?



Ty: Yes, but was so busy with other groups. So, our team just started messing around with building different things out of the Lego pieces. Or, we worked on our math or language homework. It was too hard for me to figure out on my own, so I thought that it would be too hard for me to do in high school, too. (Ty Interview, 4-2-12)

Finally, in my last interview with Danielle, a White sixth grade female student, she expressed disappointment in the second semester's Robotics class. She had been told by one of her friends, who had the Robotics class the first semester that the challenges were really fun to work out.

R: Danielle, how did you like Robotics this semester?

Danielle: I didn't like it so much.

R: Could you tell me why you didn't like it?

D: My friend told me about the 10 challenges and we never got to do them. Frankie [her friend] said that they were on the big table, but all that was there was thousands of books.

R: What did Mr. Norwood do about the challenges?

D: He told us to make one up for our team and then build a robot and make the robot car do the job. My team couldn't think of anything to do. We just played around with the Lego sets and talked to each other.

R: Were there any other teams having problems, too?

D: Yeah, all but two. One team built a basketball shooting robot and the other team built a baseball batting cage. But those were kids that had Robotics last semester, too. Most of us didn't. (Danielle Interview, 4-8-12)

This sub-category of the fragile nature of student autonomy and how that affects students' self-efficacy became an important consideration in this case study. As stated earlier, it was unexpected; however, the class observations and conversations with students have certainly proved it worthy of text.

**Student responses to instructor's constructivist pedagogy.** The core of a Multicultural Science curriculum is constructivist pedagogy coupled with socially constructed learning. As previously discussed, instructional strategies for these interdependent paradigms include communicating; learning by doing; making topics of study relevant for the students, their families, as well as their communities; and giving opportunities for student autonomy. Although students at TFCS are exposed to this pedagogy in their classes throughout the day, the final category derived from the collected data was how Robotics students responded to their instructor's methods of teaching—using constructivist pedagogy.

During interviews with several student small groups (focus groups), conversations turned toward doing science/robotics instead of just reading about science. The students spoke highly of their regular science teacher, noting that he had lots of things to touch and do in science class. Their opinions about Mr. Norwood's Robotics class followed suit. The following excerpts from focus group interviews substantiate the students' positive opinions. Groupings of students are numbered one through five. Each group had four to five students. Individual student contributions are included as one group.

R: Is the way that Mr. Norwood teaches Robotics class any different from your other classes?

- G-1: Yeah, he lets us do things on our own. We can make our own designs for our cars and we don't have to ask to get up to go get things we need, like the car parts or the other stuff we need. And, we can talk to our teams and other teams, too. Sometimes he has to say to get a little quieter, but most of the time it's all good. (Focus Group Interview [FGI], 11-12-11)
- G-2: He lets us use the computers for our robot cars, and we don't have to raise our hand to get out of our seat. We can just go wherever we need to in the classroom. He's really nice and likes to laugh. (FGI, 11-12-11)
- G-3: We get to build real robot cars that can do things – not just read about robots or watch a movie. That's so cool about science – getting to handle things. Our other science class is like that, too. We get to make things and touch all the animals. Sometimes it gets too loud in here with all the other kids in the room too. Mr. Norwood tells the boys to cool it when it gets that loud. (FGI, 12-5-11)
- G-4: I like the way Mr. Norwood helps us if we really need it. Sometimes he won't help us if he thinks we are being lazy thinkers. I think he gets that from teaching math, too. He won't give answers. He just stands there until we think through to the solution if we can. He gives hints sometimes, too. (FGI, 12-5-11)
- G-5: Mr. Norwood does not care if we speak Spanish, unless they are bad words. I like that because sometimes I cannot think of the English way to say what we need for the robot car to do or what we need from the supply

box. Other teachers don't let us speak anything but English. It is a fun class. The time goes by so fast. I wish it could be longer. (FGI, 2-5-12)

All of these students expressed positive reactions to Mr. Norwood's constructivist/social constructivist pedagogy. They found it worthy to be able to communicate with each other, even though not all conversations were strictly about the construction and programming of their robotic vehicle. Casual conversations that promote team building contribute to the overall comfort level for students in that team. Related to this was the importance of students' native languages, another component of Multicultural Science instructional strategies.

Rigor, i.e., constructive thinking (Doll, 1993) was also mentioned by several students as being important in Robotics class. Mr. Norwood curbed the amount of help he gave to students and encouraged them to solve problems through their collective thinking processes. This was closely connected to student autonomy. Without Mr. Norwood's encouragement for students to work together to solve their problems, there would be a growing dependence on Mr. Norwood to constantly provide students with solutions.

Of course, being able to actually work with real equipment to build a robotic vehicle was paramount to the value of the class, according to the students. Furthermore, the challenges gave the students the purpose and motivation for building and creatively programming their robotic vehicle. Without these challenges, students became disconnected from the purpose of the Robotics class, as was observed in the second semester class.

## **Summary**

This chapter has outlined the data collected for a case study of the Robotics class at TFCS over the course of two semesters. Three themes, or categories, were identified—the connections between the meaning of science and being a scientist, student autonomy as it is connected to student self-efficacy in science, and students’ responses to their instructor’s constructivist/social constructivist pedagogy. A sub-category was identified within the second category—the fragile nature of student autonomy and self-efficacy within the Multicultural Science classroom. Each category had strong connections with the next, which was (of course) consistent with the Multicultural Science paradigm, i.e., the connection of all things.

## CHAPTER 5

### DISCUSSION

This case study explored the components of a Multicultural Science Program with ethnically diverse middle school students enrolled in a Robotics class. The program used LEGO® MINDSTORMS® building kits and computer software for assembling and programming the robotic vehicles to meet challenges devised by the instructor, Mr. Norwood. The Robotics class was part of a Global Community Program at Tomorrow's Future Charter School (TFCS), where students chose a semester long elective class to attend as the last class period of the day.

Questions for this case study included the following.

1. What evidence of a Multicultural Science curriculum program is present in the Robotics class of the Global Community Program, as practiced and perceived by the students and their instructor?
2. What are the students' attitudes toward science, specifically with the Robotics class in the Global Community Program?
3. What responses do students have to the instructional pedagogy and learning strategies used with a Multicultural Science curriculum?

Data were collected from interviews with individual students, groups of students, the principal of TFCS, and the Robotics class instructor. Additionally, class observations were conducted during the course of two semesters of the Robotics class. Using the data collected, I explored the instructional strategies that are pertinent to a Multicultural Science Program, as they related to the ethnically diverse students in the Robotics class. Three themes were identified in the data—student perceptions of the meaning of science

and its connection to being a scientist; student autonomy and its connection to student self-efficacy (specifically in science); and students' responses to the instructor's constructivist pedagogy.

This chapter summarizes the findings of the research as they relate to the original research questions, discusses conclusions that can be drawn from the findings, and considers recommendations for teachers and students with regards to a Multicultural Science curriculum and its instructional strategies. Furthermore, this chapter will outline limitations evidenced in this particular case study, along with its value in adding to the existing research literature concerning Multicultural Science curriculum and/or programs.

### **Personal Experience**

First of all, I found it very difficult to locate a public school which had any type of Multicultural Science program in place, although programs have existed in the past 15 years. For example, The Cradleboard Project, founded by Buffy Sainte-Marie (Nihewan Foundation, 2002) was an innovative science program that sought to bring Indigenous Science and mainstream public school science together. After students in tribal schools were taught the connections between science of their culture and science in American public education, they used computer technology to teach their public school counterparts the same connections. However, as with many innovative programs, budgets were cut for public schools using this project due to the high accountability of No Child Left Behind legislation. None of the original 20 schools (tribal or mainstream public) now participate in the program. I am extremely fortunate that TFCS initiated the Global Community Program, which gave the Robotics class a home. As previously noted, TFCS is a charter school, which affords it more curriculum autonomy than the more regulated public

schools. Dr. Meeks, the administrator and co-founder, have grounded TFCS on the principles of constructivism/social constructivism, with which the Global Community Program has flourished.

Secondly, there was some difficulty with gaining trust from the students in the Robotics class, especially at the beginning of the first semester. When Mr. Norwood introduced me, I told the students that I was a student at the university and a middle school science teacher. After I explained the permission forms to the students, I told them I would be watching how they build the robotic vehicles and talking to some of them about how they feel about science and this Robotics class. When I mentioned that I may also be video-taping the class as they worked on their projects, many of the faces stopped smiling. They became adamant that their parents did not want pictures or videos of them taken by anyone at school. My plans changed; I put away the video camera for the duration of the research. Students accepted my presence about three weeks into the first semester, at which time I felt comfortable in beginning the student interviews. Since some of the students repeated the class during the second semester, knowing them hastened my acceptance by the new class of students. This was a valuable experience for me—to see firsthand how students react and adjust to a stranger “invading” their classroom.

### **Summary of Major Findings with Research Questions**

#### **Multicultural Science and the Robotics Class**

Question 1: What evidence of a Multicultural Science curriculum program is present in the Robotics class of the Global Community Program, as practiced and perceived by the students and their instructor?



Prior to collecting data specific to this research, I observed several meetings of the Robotics class to determine if it fit the Multicultural Science paradigm. Looking at the arrangement of furniture in the classroom; the use of constructivist/social constructivist instructional strategies; the encouragement of student discourse; the emphasis of the relevance of the topic, i.e., Robotics class; and the authentic assessment used in the class, I became convinced that this Robotics class did follow the tenants of the Multicultural Science paradigm. A more detailed explanation follows with Figure 6.

<b>Multicultural Science</b>	<b>Robotics Class at TFCS</b>
<b>Relevant to Students</b>	<b>Evidenced in Beginning Presentations</b>
Connections to Home and Community	Students as Engineers Completing tasks/challenges Based on Real Life Situations
Student Autonomy	Student and Team Autonomy
Communication/Discourse	Communication/Discourse (Teacher and Students)
Teachers as Mentors	Mr. Norwood – Mentor
Room Arrangement Conducive to Active Learning	Student Team Groupings Supply Cabinet Fully Accessible
Constructivist Framework	Students Actively Engaged
Social Constructivist Framework	Student Teaming
Home Language	Spanish Encouraged

*Figure 6: Comparison of Multicultural Science Paradigm and the Robotics Class.*

It is evident that the Robotics class at TFCS is an example of a Multicultural Science program. Students worked well within this realm, which is common for these students, since all school personnel use constructivist frameworks as a scaffold for their instruction. When students arrived in the classroom area, they immediately found their team members and began retrieving their supplies for that day. They enjoyed the structure and activity in the Robotics class, e.g., the freedom to move about the room, the communication among team members, and the explorations involved in building and programming their robotic vehicle. These qualities of a Multicultural Science program heightened their engagement in the building and programming of their robotic vehicles, as well as accomplishing the challenges that were prepared for them to complete.

The Multicultural Science program at TFCS also satisfied three of the characteristics of the Nature of Science (Lederman, 2007). First, students consistently made detailed observations of their vehicles' operational abilities, subsequently inferring how any necessary changes in the design would affect their vehicles' performance. Secondly, students became aware of the difference between law and theory. As students designed the programming for their vehicles' tasks, basic *laws* of physics were applied, e.g., the laws of motion. *Theories* were discussed among the team members in order to infer observable explanations of their vehicles' actions—whether or not those actions were successful. Finally, science became seen as a creative endeavor, and certainly a key factor in the Robotics class.

...even though scientific knowledge is, at least partially, based on and/or derived from observations of the natural world (i.e., empirical), it nevertheless involves human imagination and creativity. Science, contrary to common belief, is not a

totally lifeless, rational, and orderly activity. Science involves the *invention* of explanations, and this requires a great deal of creativity by scientists. (Lederman, 2007, p. 834)

It must be noted that the components of the Nature of Science were not explicitly covered by Mr. Norwood as part of his instructional strategies. Both semesters of the Robotics class began using the same presentation, which covered the history, relevance, and creativity of robotics in our global society. Throughout the first semester, students were encouraged to be creative in their thinking, i.e., develop ideas that would solve the different challenges before them. However, nothing explicitly was said relating to creativity, inferences, observations, theories, laws, and procedural methods as being components to the Nature of Science. Implicitly, these components were all part of the program, but explicit instruction concerning the NOS was not present throughout both semesters of the Robotics class.

### **Student Perceptions of Science and Their Connections to Being a Scientist**

Question 2: What are the students' attitudes toward science, specifically with the Robotics class in the Global Community Program?

At the beginning of each semester, the students in Robotics class were given a Student Science Attitude Survey (Siegel & Ranney, 2003). Students' numerical scores were converted to four categories—namely finding science in their lives (a) Very Strongly Relevant (VSR), (b) Relevant to Most Areas (RM), (c) Sometimes Relevant (SR), and (d) Strongly Irrelevant (SR). As was expected, students' responses in this survey increased dramatically in a positive direction from the beginning of the semester to the end of the semester. Since the number of students participating was small, the surveys were strictly used in developing questions for the student interviews.

As students were individually interviewed, I posed questions to them concerning statements they either strongly agreed or disagreed with on their surveys. One finding from these surveys and subsequent interviews was that students believed science to be a stand-alone discipline, rarely connecting to any other subject in school or much of their lives outside of school. Furthermore, scientists were perceived by many students to fit the stereotyped views of scientists, e.g., men who were loners and geniuses, with crazy hair, pocket protectors for their pens, and basically nerds. Their exposure to scientists was basically limited to cartoons, movies, and television crime drama. In the Science Attitude Survey (Siegel & Ranney, 2003), more than half of the students at the beginning of the semester *strongly disagreed* with the statement, “I plan on taking more science classes in high school.” When asked about this survey response, some of the students’ perceptions were threefold: (a) they did not believe they were smart enough, (b) they believed high school science would be too much work, and (c) even though they liked science classes at TFCS, they did not want their friends to make judgments about them, e.g., being a nerd. Clearly, their negative perceptions about being scientists permeated into their attitudes about science classes.

Students were more open to positive attitudes about science, as well as who can be a scientist. For example, two students from the first semester spoke to me about concentrating in computer programming when they attend high school. They enjoyed the robotic team autonomy and communication, the difficult challenges, actively constructing and de-constructing their vehicles, and being able to move around the classroom without seeking permission from Mr. Norwood.

Furthermore, their Robotics class instructor, Mr. Norwood, had a normal hairstyle, was always professionally dressed (with no lab coat or pocket protectors), and encouraged the students to work in teams to build and program their robotic vehicles. It was no surprise that the students did not think of Mr. Norwood as a scientist in the beginning of the semester, simply because of his looks and attire. In fact, they were quite surprised when he told them he viewed himself as a scientist, as well as every student in his Robotics class. This made them question their own definitions of what it means to be a scientist. It was quite gratifying to Mr. Norwood when students referred to themselves as scientists, specifically engineers.

### **Student Responses to the Constructivist/Social Constructivist Paradigms**

Question 3: What responses do students have to the instructional pedagogy and learning strategies used with a Multicultural Science curriculum?

The third theme that emerged from the data was how the students responded to the constructivist/social constructivist paradigms, which are important components to a Multicultural Science program. As their autonomy in building the robotic vehicles for the assigned tasks, so did their science self-efficacy. Students' individual and focus group interviews revealed that they enjoyed the building and programming of the robotic vehicles. They were thrilled that they could do the construction rather than watch a movie or read in a book about putting together a robotic device. Especially during the first semester, students remained on task when designing their robotic vehicles, worked well with their teammates, and overtly showed excitement with the successes of meeting their challenges. Additionally, most students wanted their turn at the computer for programming their team's robotic vehicle to meet the demands of a course challenge.

**Second semester – negative (deficit) findings.** During the spring semester, Mr. Norwood altered the Robotics class. He did not have the 10 challenges for the students to work toward solving with their vehicles. Instead, he assigned the whole class (new and returning students) to create their own challenge for their robotic vehicle. Therefore, students had to design a challenge, and then design the robotic vehicle to master that challenge. This strategy appeared to be overwhelming to the beginning students. As previously discussed, the students lost interest, became bored, misbehaved to the point of being sent out of class, and used the time to catch up on homework or just talk to friends in the class. By the end of the semester, there were only 12 of the original 20 students left in class, 2 vehicles built (although not programmed for a challenge), and an extremely frustrated Mr. Norwood. When I asked Mr. Norwood about this situation, he responded that he thought they would like designing their challenges. Indeed, that was true for the students repeating the Robotics class, but the beginning students were overwhelmed with the tasks. This scenario is an example of a negative (deficit) analysis, which means that data appeared to contradict patterns or explanations that have emerged from the previous data (Lincoln and Guba, 1985; Creswell, 2009; Patton, 2001; Strauss & Corbin, 1990).

They don't necessarily negate our questions or statements, or disprove them, rather they add variation and depth of understanding. The negative or alternative cases tell us that something about this instance is different, and so we must move in and take a close look at what this might be. Following through on these differences adds density and variation to our theory. (Strauss & Corbin, 1990, p. 109)

In consideration of causes for this negative case analysis for the second semester, I reflected more deeply on my collected data to hypothesize possible scenarios for this occurrence. Before proceeding, I want to make it clear that Mr. Norwood is an exceptional educator. During the first semester, students were engaged with the Robotics Class. They designed, built, and programmed robotic vehicles to meet the difficult challenges that Mr. Norwood had prepared. He was a constant guide and mentor to all of the students. At the beginning of the second semester, Mr. Norwood's instructional strategies continued for about three weeks, after which time he gave the students all the autonomy in their decisions and teamwork. There was very little monitoring for understanding, as mentioned for the explicit to exploratory model by Lee and Luykx (2007).

As I reviewed my data, I identified three possibilities that could have contributed toward this change. These are presumptions and not facts. First, Mr. Norwood had taught Robotics to students for many years. Since there is intensive preparation and constant student monitoring involved with constructivist instruction, Mr. Norwood could have been experiencing a "burn-out" that teachers sometimes face; he needed an easier last hour of the day during that second semester. Unfortunately, the Robotics students experienced negative consequences from his change in course.

Secondly, his challenge table was now occupied by over 100 paperback books that had been donated to the school. His typical school day was far too busy for him to organize and shelve the books, have them moved to another room, or set up a book loaning system. He stated to me several times throughout the spring semester his frustrations about his room being chosen for the donated books.

Finally, Mr. Norwood had decided to move out of state for the following school year. It is possible that he felt overwhelmed himself for his anticipated change. Together, these three situations possibly made a difference in his outlook and decisions about the Robotics class during the second semester.

Without the planning and constant monitoring of students, the Robotics class teams disbanded and students failed in their attempts to create a specific challenge, as well as build a robotic vehicle to meet the challenge. Although the returning students were assigned to be mentors for the beginning students, the returning students did not follow through with their duties. Since they had been through this program the previous semester, they knew what it took to create a challenge and design a solution. Therefore, they banded together and created two challenges for themselves: (a) a basketball shooter and (b) a baseball pitching and batting machine. After those were completed, they became more restless day after day, and finally were sent out of the classroom for extreme misbehavior. Returning and beginning students had the same problem—as their autonomy had decreased so had their self-efficacy toward creating and designing their vehicles and team challenges.

### **Working Hypotheses**

In qualitative research design, working hypotheses seek to “reflect situation-specific conditions in a particular context” (Merriam, 2009, p. 225). For example, each case study has its own generalizations, or working hypotheses, which are dependent on its overall objective, location, participants, researcher, and time constraints. “When we give proper weight to local conditions, any generalization is a working hypothesis, not a conclusion” (Cronbach, as reported by Merriam, p. 225). Patton (2002) further describes



working hypotheses as extrapolations—suppositions for the transferability of research findings to other studies that may come from similar, yet not identical, situations.

Additionally, research scholars (Creswell, 2009; Greene & Caracelli, 1997; Gibbs, 2007; Yin, 2003) have expressed caution in making generalizations for qualitative research. “In fact, the value of qualitative research lies in the particular description and themes developed *in context* of a particular site (Creswell, 2009, p. 193). Considering this literature and the specific research questions for this case study, I have derived at five working hypotheses from the data collected in the Robotics class at TFCS during the fall and spring semesters, all related to the original research questions for this case study.

- Students’ perceptions about science and scientists have an influence on their own identity, autonomy, and self-efficacy in science classes.
- A Multicultural Science program is relevant to students’ lives, shows connections to other parts of students’ lives, incorporates student-centered instructional strategies, honors/acknowledges all cultures, and encourages student discourse.
- As student autonomy increases, following the explicit to exploratory continuum (Lee & Luykx, 2007), so student efficacy in science increases. However, this autonomy and subsequent self-efficacy is extremely fragile.
- Continued monitoring and mentoring of students is a must for effective science teaching, especially using the constructivist and/or social constructivist paradigms. Acknowledgement of this difficult task is necessary for every teacher.
- Multicultural Science is appropriate for all students, in all science classes, in all schools.

## **Implications for a Multicultural Science Program**

Four implications for the development of a Multicultural Science Program are addressed in this section. All of the implications were formed from my interpretations and judgments from the data (Wolcott, 2001).

First, challenge any science program that calls for the authoritative approach in teaching science, particularly in ethnically diverse schools. Literature reviewed in this study revealed that using the traditional, modernistic approach in the teaching and learning of science with an ethnically diverse group of students is virtually ineffectual (Aikenhead, 1996; Atwater & Crockett, 2006; Barba, 1998; Basu & Barton, 2005; Hines, 2005; Snively & Corsiglia, 2003). The instructional strategies used in a Multicultural Science program emphasize a student-centered approach, rather than a teacher-centered design. Students in this particular case study delighted in the newly-found autonomy and science self-efficacy, which they experienced in this particular Multicultural Science program.

Second, incorporate Multicultural Science education into college and university science methods classes. Many teachers (preservice and inservice) believe that Multicultural Science represents topics such as learning the methods of farming and irrigation, as well as researching scientists from different cultural backgrounds. Without explicit instruction and continual experiences using the Multicultural Science paradigm, teachers will gravitate toward what they know from their own experiences—the traditional, modernistic approach to teach science.

Third, challenge any science program which does not incorporate relative, exploratory science as a regular component of the students' experiences. For years,

hands-on science has been the battle cry for successful science programs across the United States. However, without making the activities relative, they are useless. Students must be able to connect the goal of the activity to their own lives, their families' lives, their school, and their community. This connection is the heart of Multicultural Science (Barba, 1998; Cajete, 1999; Garcia, 2004).

Fourth, challenge any science curriculum that does not encourage student discourse and students' native languages. Communication is a key component of a Multicultural Science program. Students who communicate with each other to solve scientific problems, develop inferences, observe scientific phenomenon, and prepare scientific research projects develop their metacognition (awareness of one's own learning and thinking processes) and sense of worthiness within that group. Furthermore, English Language Learners (ELL) flourish with this type of science classroom. Allowing students to speak and reason in their native language contributes to their cognitive development in science. Being in an ethnically mixed group, an ELL student learns English much quicker than other ELL students who are not engaged in active discourse.

### **Limitations**

During the proposal phase of this research, two of the limitations I thought possible were language barriers and transiency of the participants. These did not pose a problem, as all students were present for their complete semester of Robotics and no language barriers were significant enough to sway the results. However, six limitations became apparent while conducting this research. First of all, time constraints imposed upon me for collecting meaningful data were extremely difficult. I would have liked to

spend full days at TFCS to observe the Robotics class members in their other classes. A case study inherently needs time.

A second limitation was the slow acceptance from the students for my presence in their Robotics classroom. Since each Robotics class was only one semester, collecting data became problematic when it took at least two to three weeks for most of the students to accept that I would be there to observe and interview them during their Robotics class time. However, as some of the students repeated the class during the second semester, there was more familiarity with me, which new students to the class noticed. Consequently, my acceptance during the second semester was not as large a limitation as first semester.

A third limitation was the time constraints involved with the Robotics class. As previously mentioned, each class in the Global Community Program was only one semester (fall and/or spring) in length. Having the Robotics course last for the full year would have given me more insights into the progression and processes of the class.

A fourth limitation to this research was the Science Attitude Survey (Siegel and Ranney, 2003). Although it is a proven instrument for science students, it is not specific for Robotics (engineering) students. Therefore, it was not used for statistical means, but rather for assistance in developing more meaningful questions for the student interviews. Its usefulness with this purpose was met.

A fifth limitation to this research was the dismantling of the Robotics class approximately four weeks prior to the end of the spring semester. Students were sent out of the Robotics class for extreme misbehavior, some became bored due to the overwhelming tasks assigned to them, and student teams dissolved. A few students

worked at putting robotic vehicles together on their own, while others did homework or visited with their friends in class. This could actually be a small limitation, considering it resulted in a negative (or deviant) analysis for the second semester, as previously discussed. Learning occurs in all situations.

Finally, a sixth limitation to this research is my personal bias. I have worked with constructivist/social constructivist science programs for over 20 years, so to say that I am a proponent of these paradigms would certainly be an understatement. However, I have shown family members and friends the data I have collected and explained to them the methodology behind this research. Three of my friends have read the draft of this research and agree on its truthfulness with the data.

### **Future Research**

Literature is abundant concerning the components and worthiness of an effective Multicultural Science program. There are studies examining Multicultural Science programs in Indigenous schools worldwide. However, empirical research involving Multicultural Science programs in U.S. public schools are virtually nonexistent. Future studies are needed to record the worthiness of such programs with ethnically diverse students.

Science methods classes in colleges and universities may or may not touch on the Multicultural Science paradigm in their coursework. Future studies are needed to examine the perceptions preservice teachers have concerning Multicultural Science. This could include longitudinal research, such as recorded with Powell (1997). He followed a preservice teacher through her student teaching experience and into the first years of

being a science inservice teacher. Such a longitudinal study would add substantially to the literature concerning Multicultural Science theory and practice.

Further research could also include the strategies of teaching science in local tribal schools and communities. How do the tribal schools differ in science instruction compared to public schools in the same district? How does the science curriculum in public schools contrast with the science curriculum in tribal or Indigenous schools?

### **Conclusions**

This research examined a Multicultural Science Program in an ethnically diverse charter school. Its objective was to observe the instructional and learning strategies of such a program, and record the student reactions to its constructivist/social constructivist paradigms. Curriculum reform for science education has been touted for decades, but little has been reported in research concerning programs that integrate the multicultural dimensions of teaching and learning with that of science instruction.

Science education has generally been on the decline in the United States for several years. Student success in science classes, as recorded with mandated standardized testing, has also been on the decline, especially for ethnically diverse students. Our society has changed, and with that, our schools must change (Strommen & Lincoln, 1992). Therefore, in order to make science available for all students, a Multicultural Science dimension should be brought into the curriculum.

This research concentrated on the students and their instructor in the Robotics class at Tomorrow's Future Charter School (TFCS). Following the guidelines of a Multicultural Science Program (Barba, 1998; Hines, 2005), students were observed and interviewed over a time-span of two semesters. (Each semester had mostly different

students.) At the conclusion of the Robotics class for the first semester, students had a positive attitude toward science, had a clearer understanding of the meaning of science, and let go of some of the stereotypical views of scientists. However, more research is needed to further substantiate these findings.

Many of us teachers in public schools are concerned about the future of science education in our country. No Child Left Behind (NCLB) legislation uses standardized testing to judge the students, their teachers, and their school community. Because of this, many innovative science programs have been cut from school district budgets, including the development of Multicultural Science programs such as The Cradleboard Project, founded by Buffy Sainte-Marie (Nihewan Foundation, 2002). In the place of most of these cut programs are, once again, modernistic and conventional science classrooms. How ironic that the NCLB legislation strives to “rescue” the at-risk students (which includes ethnically diverse students), and yet its success is measured by standardized testing that many ethnically diverse students do not understand nor respond well to its “one and only one answer” policy. Therefore, NCLB is actually causing more at-risk students to be left behind in science education. The irony is amazing.

Society has changed in our country. Schools are more ethnically diverse than at any other time in our history. In many schools, White students are now the minority in most public schools, yet teachers still instruct their students using antiquated, modernistic methods. Immediate attention to curriculum reform is vital. Multicultural Science curricula could be the bridge to bringing quality science education programs to our schools.

Furthermore, using the Multicultural Science paradigm for developing and implementing science curriculum is good for all students—not solely for students of color. It is the relevance, connections, meaningful discourse, and authentic assessment that contrasts with the instructional strategies teachers believe Western Modern Science exemplifies. Gregory Cajete (1999) is a scholar and leader in bringing Indigenous Science into tribal classrooms. In the conclusion of his book describing an Indigenous Science Education model, he noted the following.

I might also dare to imagine that some of the concepts and precepts herein expressed could *enhance the effectiveness of science teaching in any school, to any student group*. Holistic thinking can help raise the level of Western science education as well as Indigenous science education. (Cajete, 1999, p. 184)

In closing, William Doll (1993) included this quotation from Joseph Schwab in his book addressing the need for transformations in our schools. It is just as appropriate today as in 1978 when Schwab's essay, *The Practical: A Language for Curriculum*, was published.

The field of curriculum is moribund. It is unable, by its present methods and principles, to continue its work and contribute significantly to the advancement of education. It requires new principles...a new view...of its problems...[and] new methods appropriate to the...problems. (Doll, 1993, p. 161)



## Appendix A: IRB Permission Form



### Social/Behavioral IRB – Expedited Review Approval Notice

#### **NOTICE TO ALL RESEARCHERS:**

*Please be aware that a protocol violation (e.g., failure to submit a modification for any change) of an IRB approved protocol may result in mandatory remedial education, additional audits, re-consenting subjects, researcher probation, suspension of any research protocol at issue, suspension of additional existing research protocols, invalidation of all research conducted under the research protocol at issue, and further appropriate consequences as determined by the IRB and the Institutional Officer.*

**DATE:** September 14, 2011

**TO:** Dr. Janelle Bailey, Curriculum and Instruction

**FROM:** Office of Research Integrity - Human Subjects

**RE:** Notification of IRB Action by /Charles Rasmussen/ Dr. Charles Rasmussen, Chair  
/Lori Olafson/ Dr. Lori Olafson, Co-Chair  
Protocol Title: Transformative Multicultural Science: A Case Study  
Protocol #: 1107-3874M  
Expiration Date: September 13, 2012

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This memorandum is notification that the project referenced above has been reviewed and approved by the UNLV Social/Behavioral Institutional Review Board (IRB) as indicated in Federal regulatory statutes 45 CFR 46 and UNLV Human Research Policies and Procedures.

The protocol is approved for a period of one year and expires September 13, 2012. If the above-referenced project has not been completed by this date you must request renewal by submitting a Continuing Review Request form 30 days before the expiration date.

#### **PLEASE NOTE:**

Upon approval, the research team is responsible for conducting the research as stated in the protocol most recently reviewed and approved by the IRB, which shall include using the most recently submitted Informed Consent/Assent forms and recruitment materials. The official versions of these forms are indicated by footer which contains approval and expiration dates.

Should there be *any* change to the protocol, it will be necessary to submit a **Modification Form** through ORI - Human Subjects. No changes may be made to the existing protocol until modifications have been approved by the IRB. Modified versions of protocol materials must be used upon review and approval. Unanticipated problems, deviations to protocols, and adverse events must be reported to the ORI – HS within 10 days of occurrence.

If you have questions or require any assistance, please contact the Office of Research Integrity - Human Subjects at [IRB@unlv.edu](mailto:IRB@unlv.edu) or call 895-2794.

Office of Research Integrity - Human Subjects  
4505 Maryland Parkway • Box 451047 • Las Vegas, Nevada 89154-1047  
(702) 895-2794 • FAX: (702) 895-0805

## Appendix B: Initial Recruitment Letter to Participants



To: Robotics Class Students/Families

Re: Potential Participant in Science Education Research

Hello,

My name is Ms. Grimes. I am a 7<sup>th</sup> grade teacher at [hidden] District Middle School. I am also a student at UNLV preparing to do some research about your Robotics class. Do you know what “research” is? It is when one or more people try to learn more about something. Maybe you have done research yourself – like a report about an inventor, a planet, or a special book. What I want to learn and report about is how you and your classmates learn science in your Robotics class. To do this I will need to do research.

I will be video-taping your Robotics class as you work on your vehicles, and asking you questions in a couple of interviews. I will also ask you to answer some questions about how you feel about science. There is nothing to be nervous about, because there are NO wrong answers! I like that kind of work, don’t you?

Please take the attached papers home and read them with your parents. If you want to be part of this research, bring the forms back signed by you and your parents as soon as you can.

You do not have to be part of this project. It is your parents’ and your decision. No one will be mad at you if you decide against doing this. If you decide to help me with my research, your real name will never be used in the report. Also, you can ask me questions any time you want. I hope you will say yes and be a part of this study.

Ms. Grimes

grimesm@unlv.nevada.edu

## Appendix C—Student Assent Form



### ASSENT TO PARTICIPATE IN RESEARCH

#### *Robotics Class Research*

1. My name is Ms. Katheryn Grimes. I am a science teacher and a student at UNLV.
2. We are asking you to help in some research. We are trying to learn more about how students learn science in your Robotics class at IICSN.
3. If you agree to be in this study, you will be doing the following:
  - I will ask you to fill out a short survey about how you like science. There will be two surveys – at the beginning of the semester and at the ending of the semester. There are no wrong answers on this survey!
  - I will also be videotaping your Robotics class while you are there. I just want to see how your class works.
  - On two different days after school, I will be talking to you about what you like about science and your robotics class. Your teacher or Dr. Malin will be with you when we talk. You may also invite another adult to be there while we talk.
  - I may also ask you to be a part of a group of 4-5 students to talk about the Robotics class. This group meeting will be during your regular class time.
4. Your name will not be used in the research. You and your family will be able to read the research report when it is done. Any recordings will be used only for my information. The recordings will not be watched or listened to by anyone but me.
5. You may like being a part of this study by seeing how research works. You may want to be a researcher one day! You might also help to get Robotics classes started in other schools.
6. Please talk this over with your parents before you decide. We will also ask your parents to give their permission for you to take part in this study. You can still decide not to do this, even if your parents say “yes.”
7. If you don’t want to be in this study, you don’t have to. Remember, being in this study is up to you. No one will be upset if you don’t want to take part. You can even change your mind later if you want to quit.

8. You can ask me any questions that you have about the study. You and your parents may come to a meeting at school on \_\_\_\_\_ at \_\_\_\_\_ to answer any questions. You can also email me at grimesm@unlv.nevada.edu.
9. If I have not answered your questions or you do not feel comfortable talking to me about your question, you or your parent can call the UNLV Office of Research Integrity, Human Subjects at 702-895-2794 or toll free at 877-895-2794.
10. If you want to be part of this study, please print and sign your name at the bottom of this page. You and your parents will be given a copy of this form after you have signed it.

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Print your first and last names

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Date

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Sign your name

Appendix D—Parent Permission Form



**PARENT PERMISSION FORM**

**Department of Curriculum & Instruction**

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**TITLE OF STUDY: Transformative Multicultural Science: A Case Study**

**INVESTIGATOR(S): M. Katheryn Grimes**

**CONTACT PHONE NUMBER: (702) 216-4353 (IICSN office)**

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**Purpose of the Study**

Your child is invited to participate in a research study. The purpose of this study is to investigate if the robotics class at your child's school results in a more positive attitude toward science.

**Participants**

Your child is being asked to participate in the study because he/she chose to be part of the Robotics class in the Global . . . program at . . . By choosing this class, your child may have a heightened interest in science and technology.

**Procedures**

If you allow your child to volunteer to participate in this study, your child will be asked to do the following: 1) Your child will answer a science attitude survey at the beginning and ending of the semester (no names will be included on the survey); 2) The robotics class will be videotaped in order to document how the students interact with each other and their teacher; 3) Your child will be interviewed at the beginning and ending of the semester, answering some questions about what is important to them in the robotics class. These audio-taped interviews will be supervised by their teacher and/or the principal. You may also attend the interviews. 4) Focus group interviews (4-5 students together) may also be conducted 1-2 times during the semester.

**Benefits of Participation**

There *may not* be direct benefits to your child as a participant in this study. However, we hope to learn how students in the robotics class of the Global Curriculum program interact with each other and their instructors while actively "doing" science.

**Risks of Participation**

There are risks involved in all research studies. This study may include a minimal risk of the student's identity revealed. In order to lower this risk as much as possible, student names will be matched to a numbering system and no student names will be used in reporting the research. Also, parents and students will have the opportunity to read the research results and remove any part that may be questionable for your child.

**Cost /Compensation**

There *will not* be financial cost to you to participate in this study. The study will take 2 afternoons during the semester for interviews (after school – approximately 1 hour each day). The remaining research will be conducted during regular school hours. Your child *will not* be compensated for his/her time.

**Contact Information**

If you or your child has any questions or concerns about the study, you may contact Katheryn Grimes at the school’s office, (702) 216-4353. For questions regarding the rights of research subjects, any complaints or comments regarding the manner in which the study is being conducted, you may contact **the UNLV Office of Research Integrity – Human Subjects at 702-895-2794, toll free at 877-895-2794, or via email at IRB@unlv.edu.**

**Voluntary Participation**

Your child’s participation in this study is voluntary. Your child may refuse to participate in this study or in any part of this study. Your child may withdraw at any time without prejudice to your relations with the university. You or your child is encouraged to ask questions about this study at the beginning or any time during the research study.

**Confidentiality**

All information gathered in this study will be kept completely confidential. No reference will be made in written or oral materials that could link your child to this study. All records will be stored in a locked facility at UNLV for 5 years after completion of the study. After the storage time, the information gathered will be destroyed.

**Participant Consent:**

I have read the above information and agree to participate in this study. I am at least 18 years of age. A copy of this form has been given to me.

\_\_\_\_\_  
Signature of Parent

\_\_\_\_\_  
Child’s Name (Please print)

\_\_\_\_\_  
Parent Name (Please Print)

\_\_\_\_\_  
Date

***Participant Note: Please do not sign this document if the Approval Stamp is missing or is expired.***

## Appendix E—Informed Consent Form (Adult)



### INFORMED CONSENT

#### Department of Curriculum & Instruction

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**TITLE OF STUDY: Transformative Multicultural Science: A Case Study**

**INVESTIGATOR(S): M. Katheryn Grimes**

**CONTACT PHONE NUMBER: 702.769.8697**

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#### **Purpose of the Study**

You are invited to participate in a research study. The purpose of this study is to investigate how students in the robotics class at . . . , a culturally diverse K-12 school, interact with the curriculum, the instructors, and other students. Furthermore, this research aims to discover if the (hands-on) robotics class improved the students' attitudes toward science.

#### **Participants**

You are being asked to participate in the study because you fit these criteria: You are an instructor in the robotics class, an administrator at IICSN, or a parent/guardian of a student in the robotics class.

#### **Procedures**

If you volunteer to participate in this study, you will be asked to do the following: You will be asked to answer interview questions regarding the robotics class and/or the reactions of students in the program. This interview should only take a minimum amount of time. No names will be attached to the interviews or in reporting of the data collected from the interviews.

You will also be asked to attend student interviews after school, in order to maintain the students' comfort with the interview process. These interviews will take a minimum amount of time – approximately 45min. to an hour each. Only one interview will be conducted each afternoon during the interviewing process time.

#### **Benefits of Participation**

There may not be direct benefits to you as a participant in this study. However, we hope to learn how 4-6<sup>th</sup> grade culturally diverse students respond to the constructivist/social constructivist paradigm of learning in the robotics class.

#### **Risks of Participation**

There are risks involved in all research studies. This study may include only minimal risks. The only risk I foresee would be your identity being revealed. In order to minimize this risk as much possible, no names will be used in the research report, and all data will be ultimately destroyed. Additionally, you will have the opportunity to read the final research report and delete any information you find necessary.

#### **Cost /Compensation**

There will not be financial cost to you to participate in this study. The study may take up to 3 hours (total) of your time throughout the semester. You will not be monetarily compensated for your time.

**Contact Information**

If you have any questions or concerns about the study, you may contact Katheryn Grimes at 702.769.8697. For questions regarding the rights of research subjects, any complaints or comments regarding the manner in which the study is being conducted you may contact **the UNLV Office of Research Integrity – Human Subjects at 702-895-2794 or toll free at 877-895-2794 or via email at IRB@unlv.edu.**

**Voluntary Participation**

Your participation in this study is voluntary. You may refuse to participate in this study or in any part of this study. You may withdraw at any time without prejudice to your relations with the university. You are encouraged to ask questions about this study at the beginning or any time during the research study.

**Confidentiality**

All information gathered in this study will be kept completely confidential. No reference will be made in written or oral materials that could link you to this study. All records will be stored in a locked facility at UNLV for 5 (five) years after completion of the study. After the storage time the information gathered will be destroyed.

**Participant Consent:**

I have read the above information and agree to participate in this study. I am at least 18 years of age. A copy of this form has been given to me.

\_\_\_\_\_  
Signature of Participant

\_\_\_\_\_  
Date

\_\_\_\_\_  
Participant Name (Please Print)

***Participant Note: Please do not sign this document if the Approval Stamp is missing or is expired.***



## Appendix F—Student Attitude Survey

Directions: There are 20 statements (not questions) in this chart. Read the statements carefully, and then circle the number in the row that best shows how you feel about that statement.

For example:

If the statement said “I like blue more than yellow,” and you REALLY love blue, you would circle 5 (Strongly Agree) in that row.

If you like blue a little more than yellow, you would circle 4 (Agree) in that row.

If you like both colors the same, you would circle 3 (Neutral) in that row.

If you like yellow a little more than blue, you would circle 2 (Disagree) in that row.

If you like yellow MUCH MORE than blue, you would circle 1 (Strongly Disagree) in that row.

	Strongly Disagree = 1	Disagree = 2	Neutral = 3	Agree = 4	Strongly Agree = 5
1. My parents encourage me to continue with science.	1	2	3	4	5
2. I plan to take more science classes in high school.	1	2	3	4	5
3. Science helps me to work with others to find answers.	1	2	3	4	5
4. Science class helps me to evaluate my own work.	1	2	3	4	5
5. Learning science helps me understand about the environment.	1	2	3	4	5
6. Emotion (for example, love, hate, anger, happiness, sadness) has no place in science.	1	2	3	4	5
7. Science class helps me to judge other people's points of view.	1	2	3	4	5
8. Science will help me understand more about world-wide problems.	1	2	3	4	5

	Strongly Disagree = 1	Disagree = 2	Neutral = 3	Agree = 4	Strongly Agree = 5
9. Science has nothing to do with my life outside of school.	1	2	3	4	5
10. Experiments in science help me to learn with a group.	1	2	3	4	5
11. Science teaches me to help others make decisions.	1	2	3	4	5
12. Knowing science will not help me in sports.	1	2	3	4	5
13. Science has nothing to do with buying things, such as food and cars.	1	2	3	4	5
14. Knowledge of science could make it easier to fix a bicycle.	1	2	3	4	5
15. Science teaches me to think less clearly than I already do.	1	2	3	4	5
16. Making a good decision is a scientific process.	1	2	3	4	5
17. Science classes will help prepare me for college.	1	2	3	4	5
18. I am interested in learning more about computer technology and designing video games.	1	2	3	4	5
19. Learning science is not important for my future success.	1	2	3	4	5
20. Knowledge of science helps me to prevent the spread of colds/diseases.	1	2	3	4	5

## Appendix G—Student Interview Questions, Part 1

### First Set of Student Interview Questions

1. Tell me some things about yourself –
  - Favorite food?
  - Do you have any pets?
  - Do you have brother/sisters?
  - Favorite subject in school?
  - Have you always been a student at IICSN?
2. What was the last Global Curriculum program class you chose?
3. Why did you choose the Robotics class in the Global Curriculum program?
4. What 3 things do you think you will learn in this class?
5. Does it bother you that there are students younger/older than you in this class? Why?
6. Do you have friends in this class? Is that important to you? Why?
7. Are you wanting to meet new friends in this class? Is it important to you to meet new friends? Why?
8. Do you like science in general? What about science do you like the most? What do you dislike about science? Why?
9. What would you say is the meaning of science?
10. Do you think you are a scientist? Why or why not?
11. Would you ever want to be a scientist when you are older? What kind of scientist would you want to be? Why?
12. What is the best way for you to learn science? Books? TV? Videos? Teachers? Working with friends? Working by yourself? Doing experiments? Exploring?
13. What is something good about science worksheets? What is something not so good about worksheets?
14. Describe a science test that you think would show what you know about science.

## Appendix H—Student Interview Questions, Part 2

1. What did you learn in Robotics class this semester?
2. What did you like the most about the class?
3. What did you like the least about the class?
4. Did you like working with other students? Tell me about that experience.
5. If you did not understand the instructions, how did you solve that problem?
6. Do you think this Robotics class was a science class? Why or why not?
7. How could this class help you with your other classes? Explain which classes and how.
8. Could anything you learned in this Robotics class help you with what you do at home or with your family? Give examples and explain.
9. Explain what science means. What is a scientist? Explain.
10. How could you use what you learned in this Robotics class later in your life? Do you have any interest in building more robotic machines? Explain.
11. How confident do you feel about science now that you have had this class? Why?
12. Would you have learned just as much (or more) about robotics if you had read a book or watched a movie about robotics? Explain.
13. Did you work in a team? How did that work out?
14. If you worked in a team, do you think you would have had a better experience if you had worked alone? Explain.
15. If you worked by yourself, do you think you would have had a better experience if you had worked with a team? Explain.
16. Is science too hard for you? Why or why not?
17. Do you think you could be a scientist one day? Explain.
18. Would you like to be a scientist one day? Explain.

## Appendix I—Administrator Interview Questions

### Administrator Interview Questions

1. Tell me about the Global Curriculum Program at IICSN. What gave you the idea to incorporate this into IICSN's educational opportunities?
2. Why do you think the Robotics class is important to its students?
3. How have the students' parents/guardians received the Robotics class in Global Curriculum Program? Give an example of a parental response.
4. How has the program been improved over the semesters it has been in action?
5. What future does the program hold, specifically the Robotics class?
6. Does your culturally diverse population of students respond to the social constructivist paradigm, following the tenets of Vygotsky, you mention in your website? How so?
7. Do you provide any Professional Development in social constructivism to your new teachers on staff?
8. Do your teachers use this paradigm throughout the school day or only with the Global Curriculum?
9. Why do you think that the social constructivist paradigm is important for your students?
10. How do you think the Robotics experience connects to the lives of the students in the class?

## Appendix J—Teacher Interview Questions

### Teacher Interview Questions

1. Why did you choose Robotics as your class for the Global Curriculum?
2. How many semesters have you taught this class?
3. Have you taught this class in another school? If yes, were the demographics different in that Robotics class? How so?
4. What strategies have you incorporated in this Robotics class to ensure that your culturally diverse class of students feel connected and motivated to work with this curriculum?
5. What successes have you experienced in this class?
6. What difficulties have you experienced?
7. Are any of those successes or difficulties related in any way to the multicultural make-up of the class? Explain.
8. Do students of the same culture tend to gravitate together? Do you allow this or assign students to different groups?
9. Do any of the students tend to believe that one culture is better at robotics (or science) than another? Explain.
10. What do you hope that students take from this class?

## Appendix K—Student Focus Group Interview Questions

### Focus Group Questions

1. Are all of you on a team in this Robotics class? Or are you on your own?
2. What do you enjoy about this class?
3. How is it different than a regular science class?
4. Does your teacher like science? How do you know? Explain.
5. Is your teacher a scientist? Explain.
6. Are you scientists? Explain.
7. Do you think science and your other subjects could work together? For example:  
science with math – science with history – science with reading – science with  
writing – science with art – science with sports – science with cooking – science  
and math? Explain/give examples of each.
8. What is wrong with our environment? Could science help? How?
9. How do you think our environment became so messed up since “science” has  
been around for so long?
10. How can you use what you have learned in this Robotics class elsewhere (such as  
in other classes, with other friends, or at home)?

## Appendix L—Student Survey Evaluation Chart

### Interpretation of Science Attitude Scale

This appendix offers a sense of what the score numbers mean. The qualitative descriptions in this appendix are representative of responses that were close to the characteristic score. The first column provides various representative students' levels described in the other columns. The second column describes the attitude of the representative students. The third column gives examples of student responses to particular responses in the survey that would fit the attitude scoring.

Score	Interpretation: Attitude Description	Examples of Student Responses
80-73	Very strongly believes that science is relevant to life	Strongly agree with: Science helps me to make sensible decisions (Item 14). Learning science can help me when I pick food to buy (Item 13). Strongly disagree with: The things I do in science have nothing to do with the real world (Item 9).
72-62	Believes that science is relevant to most areas of life	Somewhat agree with: Science helps me to make sensible decisions (Item 14). Learning science can help me when I pick food to buy (Item 13). Strongly disagree with: The things I do in science have nothing to do with the real world (Item 9).
61-50	Believes that sometimes science is relative to life.	Somewhat agree with: Science helps me to make sensible decisions (Item 14) Learning science can help me when I pick food to buy (Item 13). The things I do in science have nothing to do with the real world (Item 9).
49-40	Strongly believes that science is irrelevant to life.	Somewhat disagree with: Science helps me to make sensible decisions (Item 14). Neutral to: The things I do in science have nothing to do with the real world (Item 9). Strongly disagree with: Learning science will have an effect on the way I vote in elections (Item 8).



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## VITA

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### Degrees:

Bachelor of Arts, Education, 1971  
Harding University, Searcy, Arkansas

Master of Science, Curriculum and Instruction, 1994  
University of Nevada, Las Vegas

### Work Experience:

2009-current - Miller Middle School, Henderson, NV, 7<sup>th</sup> grade Earth Science  
Sponsor, National Jr. Honor Society  
Sponsor, Astronomy Club

2002-2009 - Iverson Elementary School, Las Vegas, NV, K-5 grades Science  
Sponsor, Young Astronauts Club  
Sponsor, Ecology Club

1997-2001 - Lamping Elementary School, Henderson, NV, K-5 grades Science  
Sponsor, Young Astronauts Club  
Director, Christa McAuliffe Observatory Program

1990-1997 - Woolley Elementary School, Henderson, NV, 4-5 grades Science  
Director, Project S.M.I.L.E. (At-risk students as teachers program)

1987-1990 - Lois Craig Elementary School, North Las Vegas, NV, 6<sup>th</sup> grade

1971-1976 - Harding Academy, Memphis, TN, 4<sup>th</sup> grade general instructor

2003-2007 - Nevada State College, Henderson, Elementary Science Methods PI

1995-2012 - University of Nevada, Las Vegas, Elementary Science Methods PI

1990-2007 - Clark County School District, Las Vegas, NV, Professional  
Development Presenter (Astronomy, Environmental Education, Physical  
Science)

2005-2008 - OMNI Science Camp, Las Vegas, NV, Science Instructor

1993-2005 - JASON Project, Las Vegas, NV, Curriculum Instructor

Special Awards and Honors:

2010	Golden Key National Honor Society, UNLV, Las Vegas, NV
2009	Phi Kappa Phi National Honor Society, UNLV, Las Vegas, NV
2008	Nevada State College of Education, Part-time Instructor of the Year
2006	Nevada Wildlife Federation Conservation Educator of the Year
2000	NASA Solar System Educators Fellow, JPL – Pasadena, California
1999/93/91	Christa McAuliffe Fellowship Awards
1998	KLVX, Channel 10, NTTI Master Teacher Award
1997	Outstanding Nevada Educator (O.N.E.)
1996	NASA NEWEST Fellow, Stennis Space Center, Biloxi, MS
1996	Finalist Disney American Teacher Awards
1996	Milken Family Foundation National Educator Award
1994	Presidential Award for Excellence in Teaching Science - National Award
1994/93	Nevada Presidential Awards for Excellence in Teaching Science
1993	Nevada Mining Assoc. Geosciences' Teacher of the Year
1976	Harding Academy Teacher of the Year, Memphis, TN

Presentations and Publications:

2012	Grimes, M., Bailey, J. (2012). Multicultural Science: An Action Research with Preservice Teachers. <i>Proceedings of the National American Science Teachers Association Conference</i> , Clearwater Beach, FL.
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- 2010 Grimes, M. (2010). Bridging the Gap between Western and Indigenous Science. *Proceedings of the Society for the Advancement of Chicanos and Native Americans in Science (SACNAS) National Conference*, Anaheim, CA.
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- 2000 – 2003 JASON Project National Conference curriculum presenter, Milwaukee, WI.
- 1998 Grimes, M. (1998). Performance Assessment and Critical Thinking. *Proceedings of the Critical Thinking National Conference*. Las Vegas, NV.
- 1997 – 2000 Grimes, M., *KLVX National Teacher Training Institute*, Curriculum presenter, Las Vegas, NV.
- 1996 Grimes, M. (1996). Students as Teachers in Geoscience. *Proceedings of the Western Regional Mining Association Conference*, Scottsdale, AZ.
- 1996 Grimes, M. (1996). At-Risk Students-as-Teachers in Science. *Proceedings of the West Texas A & M University Science Education Conference*, Canyon, TX.
- 1995 Grimes, M., Powell, R. (1995). The Influence of a Transformative Science Curriculum on At-Risk Students. *Proceedings of the National Association for Research in Science Teaching National Conference*, San Francisco, CA.
- 1995 Grimes, M. (1995). Teaching Science with Natural Analogues. *Proceedings of the International High-Level Waste Conference*, Las Vegas, NV.

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Professional Organizations:

American Indian Science and Engineering Society (AISES)  
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National Science Education Leadership Association (NSELA)  
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Transformative Multicultural Science Curriculum: A Case Study of Middle School Robotics

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