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Minority Middle and High School Students' Interest in Science: An Exploration of Teachers' Perceptions

Caroline Makere

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MINORITY MIDDLE AND HIGH SCHOOL STUDENTS' INTEREST IN SCIENCE: AN EXPLORATION OF TEACHERS’ PERCEPTIONS

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Curriculum and Social Inquiry

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of the requirements of
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Abstract

A high school teacher conducted a study about minority middle and high school students’ interest in science. The problem was to find out why African American and Hispanic students were showing very little interest in science. The researcher used four middle school science teachers and nine high school science teachers, all from inner city schools in a big city of the Midwest United States except for one middle school teacher from a nearby suburb. The participants answered a survey questionnaire followed with a face-to-face recorded interview. The findings of the study confirmed that students showed little interest in science due to a myriad of reasons. Overall, the students preferred to work in small groups and to do labs and activities, and did not like to be lectured, to take notes, or to read science materials. This study could be useful to teachers in similar environments with similar populations.
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DEDICATIONS

I dedicate my lifetime achievement, this dissertation, to my parents, Matia and Makidalena, who, although they have passed on to the other world, I know were looking over me and leading me in finishing my work. I would also dedicate this work to my brothers and sisters who are with my parents. I know they were cheering me on and sometimes yelling at me when I felt that the work was too much for me to complete. These are their names: Elizabeti-Namangi and Navoneiwa-Namsi, my sisters, and my brothers Enea-Manda and Davidi-Mhako.

I dedicate this dissertation to my best friend Caroline Presnell (“CP”), my editor for this work. Without you CP, this work could not have been done. Many thanks to my friend Edie Heinemann: your contributions and leadership in writing were a backbone of my work. My best friend Steve Brooks’s commands of “Get it done!” and “Make it worth the time!” were a catalyst to surmounting the hurdles I thought were hard to jump over. My best friend Diane Wright and her husband Richard Wright and their entire family have been there for me countless times.

Most important are my thanks to my three children, Allen-Lebulu, Alessandra-Elinzia, and Elias-Alewinga, for your patience during all this time, especially for the many Thanksgivings and Christmas holidays when it consumed my time instead of being with all of you. Your concerns about why it has taken this long to finish were taken to heart, and I thank all three of you for your support. This dissertation is yours, and you know very well that if I can do this, you can too—ten times faster and better.
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CHAPTER ONE

INTRODUCTION

Do We Need Another Sputnik? (Bybee, 2007)

Anyone who is involved in K–12 education in large cities has asked similar questions at one time or another. For example, how is it possible that a high school student does not know that seeds like beans or corn come from plants and that they can be grown to become plants that will produce the same seeds again? Or that the milk they buy from refrigerators in grocery stores comes from cows? How can they be so removed from the realities of life? Don’t these questions sound ridiculous? Almost unreal? Unfortunately, these are real questions teachers ask about real high school students. So, it is no surprise that in 2007 Bybee was thinking back to the Sputnik era. (The relevance of Sputnik will be explained further in here and in Chapter 2 - literature review.)

This chapter will cover the following:

- Explanation of the research purpose
- Definition of “interest” as used in this study
- The target population
- What questions the study will address
- Research frameworks
- Organization of the paper

As a science teacher at a Midwest urban high school, I have had enough concerns about what I observed as very little interest in science from my students that, had I had written them down, they could fill a volume. This is the reason why I thought I should find out if other teachers have had similar experiences or if I am an outlier.
Purpose of the Study and Definition of Terms

The purpose of this study was to investigate why inner city minority students have very little interest in science. Why should my research focus on science? That is what I teach. I am dealing with my own problem, one I know very well, firsthand. But I hear similar concerns from many other inner city science teachers who express the same concerns about their students’ disinterest in science.

There are many terminology associated with “interest.” These are words like: attitudes to or towards, favoring/disfavoring, liking/disliking, motivated/unmotivated, and choosing/not choosing. Any or all of these words as used in this study refer to interest. Therefore, the term “interest” in this study means simply the tendency of students to be excited about science, to want to participate in school and pass their classes. It can also extend to references to activities students engage in on their own outside of school. This will be the guiding understanding of the term from this point forward.

I have taught science (biology, earth/space science, environmental science, and sometimes chemistry and physics) for 13 years in the same school district, so this study is very personal to me. The majority of students I teach are students of color—Hispanics and African Americans. I position myself as an action researcher wishing to improve my teaching from the findings of my study. I also wish to inform others in similar situations: teachers, administrators, parents, and policy makers.

Evidence of very little Interest

The perception I have about my students is not unique. I have heard and read laments from other teachers and from scholars around the world. There is enough literature to suggest that there is a developing trend in the industrialized countries of
North America and Western Europe of students’ dwindling interest in science (e.g., Mullis & Jenkins, 1988; Murphy & Beggs, 2003; Simpson & Oliver, 1985, to mention but a few). Researchers add that this declining of interest starts at the time students are between the ages of 9 and 11, and by the time they reach age 14, the rate of decline is drastic (Ebenezer & Zoller, 1993; Tai, Qi Liu, Maltese & Fan, 2006).

Ramsden (1998) called all stakeholders to action because she noticed that there was not enough literature about the issue in the 1980s and 1990s as compared with what was available in the 1970s. Likewise Bybee (2007) used Sputnik as a metaphor to remind all stakeholders that it had been 50 years since Sputnik was launched. Before then, as those old enough to remember Sputnik’s beep-beep wake-up call might also remember, the society was complacent with the status quo—or so it seemed. The message is that the American societal educational momentum in science is worn out similar to the times before Sputnik. The condition is even worse among minority students. (Further discussion on Sputnik will continue in Chapter 2.)

I would like to add that Rising Above the Gathering Storm, the report from the National Academies’ Committee on Science, Engineering, and Public Policy (COSEPUP, 2006) on bolstering the U.S. economy by focusing on STEM (science, technology, engineering and mathematics), came too late. This report was written by the National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine. The storm was already here: the skills which are needed for the twenty-first century global economy—such as problem solving and critical thinking—are missing in the teaching and learning of science education in poor school districts (Bybee, 2010;
Sneider, Stephenson, Schafer & Flick, 2014). (More about STEM education will be covered in the literature review in Chapter 2).

Reported statistics indicate that non-Asian students of color have been lagging behind their White and Asian peers for a long time now. (See, for example, the National Assessment of Education Progress (NAEP), 1996; the Program for International Student Assessment (PISA), 2006); and Trends in International Mathematics and Science Study [TIMSS], 2011). All these assessments have reported that African American students’ achievement has been lower than all the other ethnic groups’. This adds to my purpose for doing this study, since the majority of my students are members of minority groups, and I am a member of a minority group as well. (NAEP, PISA, and TIMSS will be detailed in Chapter 2.)

Researchers predict (e.g., Huntoon & Lane, 2007; Schmidt, 2003) that by 2025 there will be an additional 5.6 million school age children in the United States, and that 93% of them will be Hispanics. These authors claim that Hispanics are the least represented in professional STEM fields. According to Bybee (2007 & 2010) and Friedman (2005), unless something is done there will be an economic downfall later on in this century in the United States because the workforce will not be ready to drive the economy forward. Another aspect is the United States’ leadership position in the world, which might suffer now that there are more competitors in comparison to the Sputnik era. The United States will not be competing with countries like Canada, the United Kingdom, France, and Germany alone, but also the very competitive rising economic powers of Asia (China, Japan, India, Hong Kong, Singapore, South Korea and Taiwan)—
the so-called tiger economies (Ceglarek & Yu, 2001; Haukoos & Chandayot, 1998; Yahuda, 1993).

Friedman (2005) claimed that K–12 science education is not stimulating enough to have young people want to go into STEM fields. He went on to say that it takes 15 years to make a scientist, and, not astonishingly, who would want to be in such a dull situation that long? Certainly not a young person. Friedman’s point is well taken, and that is why there is need to find out what it is that students want in order to rectify the conditions. Raising their motivation by making science interesting is the first step. Among the many scholars who acknowledge the importance of interest in learning are Dewey (1913); Hidi (1990); Hidi & Baird (1986); Hidi & Harackiewicz (2000); Hidi & Renninger (2006); Krapp (1999); Krapp, Hidi, & Renninger (1992); Osborne & Dillon (2008); and Schibeci (1984). The discussion about interest and learning will be further detailed in Chapter 2 of this paper.

**Research Objective**

My main objective was to investigate from the perspectives of teachers of students of color what their experiences had been in teaching science. The study will be a contribution to the knowledge base on students’ interest in science. When I was looking for information about this topic I found more literature by scholars in Europe (e.g., Ramsden, 1998; Sjöberg & Schneiner, 2006; White & Harrison, 2012) than in the United States, and this was an added stimulus to my motivation. This study looked into answering the following questions:

1. What factors have robbed students of their interest in science as they moved from grade school through middle school to high school?
2. Have students read, or heard from family, teachers, or peers anything about science that made them not interested in science?

3. In what ways do students see the importance of science to them as individuals and to society in general?

**Conceptual Frameworks**

This study was informed by Critical Race Theory and Latina/Latino Critical Theory, altogether shortened as CRT/LatCrit frameworks. These frameworks developed from legal scholars of color and their allies who pushed the envelope further after cases like Brown v. Board of Education (1954) and the enactment of equity laws like the 1964 Civil Rights Law. These legal scholars’ purposes were to bring awareness to areas of education on matters of equity, particularly in dismantling white privilege and institutional hegemony. These frameworks were chosen for this study based on my assumptions as to why these inner city students of color have very little interest in science. These assumptions will be discussed in detail in Chapter 2. According to CRT and LatCrit, students of color are silenced either directly or indirectly by the simple fact of belonging to marginalized groups in the larger society (Crenshaw, Gotando, Peller & Thomas, 1995; Delgado, 1995; Ladson-Billings, 1998; Tate, 1997).

**Summary**

The introduction chapter has covered the purpose of this research, which was to find out why students have very little interest in science, and to examine its significance given that the future economy will depend very much on careers in the fields of science, technology, engineering, and mathematics. Our students in the United States face a challenge in this future economy compared with students in other industrialized countries.
(Bybee, 2007; 2010; Friedman, 2005). Students of color will face even more challenge than Whites and Asians because their performance is already low.

In this chapter, the research questions have been identified; the definition of “interest” as the researcher defines it for use in this study was given. Next, Chapter 2 will examine in detail the literature available about students’ interest, in science. Chapter 3 will discuss methodology, and Chapter 4 will cover data collection and analysis. Finally, Chapter 5 will discuss the findings and their meaning, summarize the study, and identify limitations and possible improvement of the study for the future.
CHAPTER TWO

REVIEW OF THE LITERATURE

The Black-White Achievement Gap

The Black-White achievement gap is recognized as a persistent challenge for urban science education, based on historical sociocultural analysis (e.g., Obed, Ault & Bentz, 2001). In this chapter I will show the evidence available from national and international assessments that African American and Hispanic students are underperforming their White and Asian peers. Then I will explain the theoretical framework that provided the foundation for the study. This will be followed by my assumptions about the causes of students’ diminishing interest in science and discussion of supporting literature about factors that have been found to cause academic failure in minority students. I will then embark on a lengthy narrative about one of the misused scientific theories of the past that I suspect might still affect students of color in science today—the theory of eugenics. After the narrative on eugenics, I will elaborate on other factors that according to literature have caused decline of interest in science and support my assumptions by citing studies done by researchers in those fields. Then I will spend a great deal of time discussing the history of science education in the United States—how science was the latest field to enter formal education, how different fields’ curricula were developed, and the important people who participated and organizations that were formed with varying capacities to affect education. This historical portion of the chapter will also touch on politics in different eras and will link the overall history of education and science education to particular reforms in science curricula development during various periods and under several presidents, up to and including the current day.
I made the assumption that very little interest is causing students of color to underachieve in areas of STEM education. Other researchers have looked at a myriad of other factors that can affect educational achievement; for example, the socioeconomic status (SES) of minority populations, which results in inadequate resourcing of the schools that many minority students attend (Hanushek, 1997; Kohl, 1936; Kozol, 1991, 1992, 2005; Rodriguez, 1997), including patterns of school funding (Baird, 2012; Baker & Corcoran, 2012; Education Trust, 2005). Additional factors that are discussed in the literature are:

The upbringing of children and home life in general

Race

Socio-cultural issues
(Obed, Charles & Bentz, 2001)

Segregated schools whose students are almost entirely minority and poor children
(Beatty, 2013; Cross, 2007; Sohoni & Saporito, 2009)

Gender
(Baker & Leary, 1995; Catsambis, 1995; Kahle & Meece, 1994)

Inequality of opportunity
(Carver, 1975; Coleman et al., 1996; Jencks, 1973; Mosteller & Moynihan, 1972; Wößmann, 2004).

Another focus is examining students’ perceptions of science and scientists (Chambers, 1983; Mead & Metraux, 1957; Jackson & Rich, 2014; Packard & Wong, 1999). This is a
mere speck of the literature available. Some studies from this list will be further
discussed in detail in this chapter.

**Causal Factors**

According to Bybee (2010), there are five scientific challenges for success in the
twenty-first century. These are: achieving scientific literacy, reforming science programs,
teaching science as inquiry, improving science teachers’ knowledge and skills, and
attaining higher levels of achievement for our students. I agree with Bybee on these five
challenges, and I would add a sixth challenge, which is increasing students’ interest in
STEM education. If students show very little interest, it will be hard to accomplish his
five challenges. Schools have to undo some educational misconceptions students bring
with them to school and at the same time embrace and accommodate students’
experiences in order to evoke interest and excitement to learn. It is hard to strike a
balance between what students walk into school with and what the school wants to instill
in them. The quote below sums up this point nicely.

> Those who teach science have come to a universal observation: Students’ behavior
> is influenced by the values they hold, the motivation they possess, the beliefs they
> bring from home to the classroom, and the myriad attitudes they have formulated
> about school, science and life in general. The key to success in education often
> depends on how a student feels toward home, self, and school. (Simpson, Koballa,
> Oliver, & Crawley, 1994, p. 211)

**Academic Achievement Measures**

I will now focus on how American students’ academic performance is assessed at
home and evaluated by international ratings. This will show that American students are
not the top performers in international assessments, but that Whites and Asians fair better compared with Hispanic and African American students.

Several assessment projects provide yardsticks for academic achievement. The National Assessment of Education Progress (NAEP) has been administered at a national level since 1969. The national assessments were followed by state assessments, which began in 1990. The Trial Urban District Assessment (TUDA) began in 2002. National and state results are usually released at the same time, but district results are released two weeks later. The Elementary and Secondary Education Reauthorization Act (2001) requires that NAEP administer reading and mathematics assessments for grades four and eight every other year in all states. These two subjects are tested on a national representative basis at grade 12, at least as often as it has been done in the past or every four years.

Administering long-term trend assessments in reading and mathematics at ages 9 and 13 and at grade 12 is also required. In addition, other subject matter, including writing, science, history, geography, civics, economics, and foreign languages, is assessed depending on the availability of funds. NAEP requires a participating school to have a random selection sample representative of the school’s student population to participate in the assessments. Each student is assessed in only one subject. The scoring scale ranges from 0 to 300. In science assessments for fourth graders in 2009 and 2011, White students’ average score was 163; African American students averaged 127; Hispanics 131; Asian/Pacific Islanders 160; and Indian/Alaskan natives 135. So, African Americans, Hispanics, and Indian/Alaskan native students had lower scores than White
and Asian ethnic groups. The scores for the eighth graders were not significantly different across ethnic categories from when they were fourth graders.

According to Archer et al. (2012), promoting positive attitudes about science is the most important attribute for science outcomes, and this is supported by Hidi and Baird (1986) and Hidi and Renninger (2006). Results from the 1996 NAEP science assessment showed that attitudes toward science varied significantly for boys and girls and members of different groups, particularly by 12th grade. Women and minorities are at risk for low achievement, and this in turn results in poor self-efficacy in their ability to do science. Researchers (Haukoos & Chandayot, 1988; Simpson & Oliver, 1985; Weinburgh, 1975) suggest that the poor performance of minority groups and women stems in part from their more negative attitudes and beliefs about science. Gender is not so much a concern for the current study because, in the course of my teaching, if there have been students who showed interest in science they mostly have been girls. I thought it would be interesting, however, to see what the results of the study would show about the experience of other teachers.

Ever since the 1960s the United States has participated in international comparative assessments in mathematics and science. The Program for International Student Assessment (PISA) and the Trends in International Mathematics Science Study (TIMSS) are of interest. Looking at the most recent in 2011 (National Council for Educational Statistics [NCES], 2013), 57 countries participated fourth graders, and 56 countries with eighth graders. The United States participated with a national sample comprised of public and private schools; and some states participated independently. U.S. states’ scores were compared to the U.S. national average score. All scores were
statistically significant at the .05 level, and no adjustments for multiple comparisons were used. In mathematics, U.S. fourth graders’ average score was 541, which was higher than that of the international average of 500. The United States was among the top 15 education systems. Comparing this performance to that of 1995, U.S. fourth graders scored 12 points higher (529 vs. 541). The average mathematics scores for eighth graders in 2011 was 509 out of the 500—the TIMSS score average. The United States was among the top 24 education systems. Comparing 2011 with the 1995 score of 492, the eighth graders performed better by 17 points (492 vs. 509).

Science scores for fourth graders 2011 were 544, which surpassed the TIMSS average score of 500; the United States was among the top 10 education systems. There was no significant difference between 1995 and 2011 (544 vs. 542). In science, eighth graders’ average was 525, placing the United States among the top 23 countries; there was a gain of 12 points from 1995 (525 vs. 513). The most important feature of this assessment for this study is how students performed by ethnicity. In 2011 the average science scores for Whites, Asians, Hispanics, and multiracial fourth graders were higher than the TIMSS scale average; but for U.S. African American fourth graders the average was lower. When the racial scores were compared against the U.S. national average, both African Americans and Hispanics had lower averages compared to their peers in White, Asian, and multiracial groups.

Another characteristic of TIMSS that is of interest to my study is students’ interest in science. The 1996 TIMSS survey measurement of attitudes toward science revealed that 78% of students in England reported liking science or liking it a lot; and more than 80% of pupils from different countries reported liking science: 93% Iran, 92%
Singapore, 90% Thailand, 89% Kuwait, and 87% Columbia (Beaton et al., 1996).
Judging from these higher percentages of children who reported liking science, one might wonder why undertake a study on decreasing interest (the current study). What the researchers, Beaton et al. (1996) and Seymour & Hewitt (1997), found was that there is a progressive decline in interest between the ages of 10 and 14. The majority of students I teach are between 14 and 15 years of age. So, following these researchers’ findings, it means that by the age of about 14, students might have lost much of the interest they ever had in science. Therefore, these high percentages of students around the world who indicated that they liked science or liked it a lot were much younger (Beaton, et al., 1996; Hewitt, 1997). I was interested in finding out if my students liked science when they were in grade school and middle school and, if so, find out what robbed them of that interest.

The report of the Program for International Science Assessment (PISA) compares U.S. students with students from U.S. economic competitor members of the Organization of Economic Cooperation and Development (OECD) and with nonmember countries that participate. The United States was among the 57 countries that participated in PISA 2006, totaling 30 OECD countries and 27 partner countries. The U.S. average score was 489 (11 points below the OECD average of 500). U.S. students ranked 17th among other industrialized (OECD) countries. Sixteen OECD countries scored higher than the United States. Examples: Finland (563), Canada (534), Japan (531), New Zealand (530), and Australia (527). Examples of partner countries that scored higher than the United States are: Hong Kong (542), China-Taipei (532), Estonia (531), Liechtenstein (522), Slovenia (519), and Macao (511). In 2000, the United States was ranked 14th compared to 19th in 2003. Finland’s students had the highest score of all at 563, which was 74 points above
the U.S. students’. Looking at science literacy scores for racial and ethnic groups in the United States, African American students and Hispanic students had statistically significant lower scores at 409 and 439 respectively. White students scored an average of 523, which was above the OECD average. Asian students scored 499, and mixed race students scored 501. This racial/ethnic performance finding is similar to that of PISA 2003 (Baldi et al., 2007).

PISA also rates proficiency levels of the scores using a one-to-six scale based on least to most difficult tested items. To be clear about this, for students to be categorized as level six it means that they can constantly recognize, explain, and relate both science knowledge and knowledge about science in varied, complex situations. OECD countries had 1.3% of their students perform at level six; the United States had 1.5% at level six. If level five and level six performers were combined, the U.S. students would have performed equally to the OECD average, which was 9.0%. That would have been good, but other countries performed at levels five and six with higher percentages. Finland, for example, had 20.9%; New Zealand had 17.6%, and Japan, 15.1%. Level two was chosen as a baseline for PISA- 2000. To clarify, at level two, students can recognize major features of a scientific study, recall ideas, and use the provided data to support a personal decision. Across OECD, 19.2% were categorized as below the level two baseline. For the United States this average was 24.5%. That is, students who are below level two may fail to sort out the major ideas of an experiment, may apply wrong scientific information, and may confuse scientific evidence with personal opinions and beliefs.

Proficiency levels for racial and ethnic groups were also reported. African Americans, Hispanics, American Indian, and Native Alaskan scored below the OECD
average. White students scored above the OECD average. Whites, Asians, and Mixed race students averaged level three proficiency. Hispanics, American Indians, Native Alaskan, Native Hawaiian, and other Pacific Islander students averaged level two proficiency. However, the average mean score for African American students was level one proficiency (Baldi et al., 2007). PISA, unlike TIMSS and NAEP, assesses scientific literacy, basically to explore what 15-year-olds’ ability to apply scientific understandings to life situations involving science is. PISA does not assess curricula per se, but the application of knowledge from these curricular to real life situations; in order to improve overall human conditions in science and the technological world, especially now in the twenty-first century.

PISA also assesses how skillful students are in intellectual, cultural, and environmental aspects by addressing the following questions: Are students willing to engage in science-related issues as constructive, concerned, reflective citizens? Can students demonstrate the ability to use conceptual models to explain natural phenomena? Can students formulate explanations to evaluate the same phenomena and communicate it with accuracy? These same questions are addressed by the new science standards—Next Generations Science Standards (NGSS) (National Research Council, 2011). It is interesting to see the similarities of NGSS and the concepts assessed by PISA.

Due to concerns that other developed countries and some developing countries are outperforming the United States in science, President Obama has vowed to reestablish science to its rightful position. He allotted more than 3% of the gross domestic product (GDP) to research and development under the American Recovery and Reinvestment Act (ARRA 2009). The president’s address to the 146th Annual Meeting of the National
Academy of Sciences in April 2009 followed these lines—that U.S. students are not at the top in scientific literacy, nor are they at the bottom; but their performance is of concern for the United States, particularly in maintaining America’s position of leadership in science and technology in the twenty-first century (President Barack Obama, 2009). This is echoed in Bybee (2009); and Bybee (2010). President Obama is concerned about American students’ performance in national and international assessments in the STEM fields, and about the future of the twenty-first-century workforce if education problems are left unabated. Obama challenged the attendees to the National Academy of Science by saying, *use your love and knowledge of science to spark a sense of wonder and excitement in a new generation.* His secretary of education, Arne Duncan, was equally concerned; he echoed the president’s comments at the Organization for Economic Cooperation and Development’s (OECD) release of the Program for International Student Assessment (PISA) 2009 results. He urged Americans to wake up to the realities of education as other industrialized nations are out-performing the United States, and added, *As disturbing as these international trends are for America, enormous achievement gaps among Black and Hispanic students portend even more trouble for the United States in the years ahead.* (http://www.ed.gov/news/speeches/secretary-arneduncans-remarks-oecds-release-program-international-student-assessment-pisa-2009-results).

Arne Duncan indicated that he was in favor of national curricular standards. He did not think that having 50 different standards for education while other developed nations adhere to uniform national standards was a good idea (Lee, 2009). Historically, there have been important educational thinkers who supported individual states’
educational goals thinking that they created diverse and challenging educational experiences. A good example is James Conant (1953). International academic competitions, if they continue, might force countries to abandon their own standard curricula and begin to follow the international trends, as Germany and South Korea have done (Lee, 2009). Interest in scientific literacy started in the mid-1940s (Holton, 1998), greatly influenced by the ideas and impetus of James Bryant Conant, as explained by Paul DeHart Hurd under the title, *Science Literacy: Its Meaning for American Schools* (Hurd, 1958). Conant’s emphasis was on teaching students scientific skills to prepare them as future citizens, not just as future scientists. The importance of teaching science literacy is supported by the PISA assessment, which is designed to find out if students are taught skills like how to acquire scientific knowledge; the process of asking questions to get new information; how to collect evidence to support scientific claims before they make conclusions about a scientific phenomenon (Bybee, 2010; Next Generation Science Standards [NGSS] National Academies’ National Research Council 2011); and to discover whether students understand that science is a process by which humans acquire knowledge through inquiry.

**Conceptual Frameworks**

**Critical Race Theory and Latina/Latino Critical Theory (CRT/LatCrit)**

I chose to use CRT/LatCrit concepts to frame the current study as a means to inform the reader about the complicated conditions African American and Hispanic students experience as members of marginalized groups in our society. Further, belonging to marginalized groups could in itself create problems for students that contribute to their diminished or total loss of interest in science. Both CRT and LatCrit
are appropriate here because the students being reported on by the teachers in my study come from populations of students of color. These two frameworks were the lenses through which I entered into the spaces of these minority students, as a member of minority groups myself, hoping to understand what other teachers have observed or not observed. The principal sources for the conceptual development are Crenshaw (1995, 2011), Delgado Bernal (2002), Ladson-Billings (1998, 2005), Ladson-Billings & Tate (1995), Solorzano & Yosso (2001), and Tate (1997).

According to Ladson-Billings (1998) and Delgado Bernal (1995), CRT took root from earlier legal movement called Critical Legal Studies (CLS) in the early 1970s. The individual credited for this work is Derrick Bell (Bell, 1987, 1999, 2004), with allies like Alan Freeman who were concerned about the slow pace of racial reforms in America. Credit is also due to Gramsci (1971) for his conception of “hegemony” ideology, which he understood to be a continued unawareness and unquestioned acceptance of oppressive structures in European society in general and the Italian society in particular. CLS started as a critique of the legal ideology portraying American society as a meritocracy such that if one works hard enough he/she must eventually realize the American dream. CLS criticized this philosophy because it fell short of acknowledging that racism was still alive and the assumption of a colorblind society was a myth, not a reality.

Such legal scholars of color and their partisans realized that there were essential and ingrained gaps in the ideology between the theory (enacted laws for civil rights and education) and practice of law and racial power. This is how CLS was born. CRT reached the general public through these legal scholars’ telling of convincing stories rooted in legal matters; and this method was able to extend its roots to education because of the
nature of education in teaching using narrative as an inquiry (e.g., Bernal & Villalpando, 2002; Duncan, 2005; Solarzano & Yosso, 2001; Villena & Deyhle, 1999; Wallace & Brand, 2012). The late Professor Bell engineered CRT from his *Harvard Law Review* writings from 1970-1976; an example of his writings includes, *Serving two Masters* (Bell, 1995a, in Delgado, 1995). Bell’s writings are the blueprint for CRT (Hughes, Noblit, & Cleveland, 2013; Minow, 2012).

CRT can usefully be applied to all areas of education from curriculum, instruction, and assessment to school funding. If educators continue to operate under the idea that students of color are deficient, they will continue to spend much of their time trying different methods to deal with the deficit, then the curriculum for these students will continue to be remedial in relation to that of White and Asian students, who are perceived to have no deficit (Delgado Bernal, 2002; Ladson-Billings, 1998). Some writers call on educators of minority students to allow these students to demonstrate what they know—to function as contributors to the curriculum rather than passive receivers of knowledge (e.g., Ladson-Billings, 1998; Villena & Deyhle, 1999).

In assessment, CRT reminds educators how in the past, under the influence of pseudoscientific theories, tests were used to try to prove that Blacks were intellectually inferior to Whites. According to Crenshaw (1988), intelligence testing created racial stereotyping of Blacks and other minorities; he claims that these hegemonic roles affect all people across different ethnic groups, genders, and socioeconomic classes. So then, instead of testing to find out what students do not know, educators should test in ways that will allow students to demonstrate what they know.
Kozol’s *Savage Inequalities* (1991) exposed the realities of school funding in the country, especially in large cities. School funding more than anything else demonstrates a function of institutional and structural racism, according to Kozol and some CRT authors. Since every state funds its schools based on property taxes, it is obvious there will be disparities in per pupil spending depending on where the schools are located; CRT argues that the government has a responsibility to take into considerations school funding as one of the key factors creating inequality in education. Despite the fact that some researchers find no direct correlation between school funding and students’ achievement (e.g., Hanushek, 1986, 1996, 1998), others (e.g., Baker & Corcoran, 2012; Greenwald, Hedges, & Lane, 1996; Kozol, 1992) disagree, and see a correlation between funding and students’ achievement.

LatCrit is similar to CRT only in that its creation and main focus is to address issues pertaining to people of Mexican origin and other groups from Latin American countries. The following researchers have written extensively about LatCrit: Bernal & Villalpando, 2002; Solarzano & Yosso, 2001; Villena & Deyhle, 1999; and those included in the *LatCrit Primer, Vol.2*, 1999. Delgado Bernal (2002) defines LatCrit as follows:

Chicana/Chicano are cultural and political identities that were popularized during the Chicano movement of the 1960s. They are composed of multiple layers and are identities of resistance that are often consciously adopted later in life. The term *Chicana/Chicano* is gender inclusive and is used to discuss women and men of Mexican origin and/or other Latinas/Latinos who share similar political consciousness. Because terms of identification vary according to context and not
all Mexican-origin people embrace the cultural and political identity of Chicana/Chicano, it is sometimes used interchangeably with Mexican (p.121).

LatCrit brings into the fore what is missing in curricula and instruction of Latina/Latino, Chicana/Chicano population of students. According to LatCrit, students are creators and holders of knowledge, but Eurocentric epistemology has ignored the contributions made by minority groups. Scholars of LatCrit look at the oppression of people of color in categories of race, gender, and class (e.g., Delgado Bernal, 1998; Ladson-Billings, 1995, 2000). CRT and LatCrit frameworks challenge the dominant liberal ideology of color blindness.

LatCrit explains that Latina/Latino–Chicana/Chicano students bring to schools their bilingualism, biculturalism, perhaps experience in the migratory work force, and their strong commitment to family and communities. Sometimes students from these groups find themselves in a quandary as to whether or not they should pursue their individual interests or do what is right for their families and communities, and most of the time they choose the latter (Valdes, 1996). Latina/Latino–Chicana/Chicano cultures are similar to African American culture particularly in the way young children learn from stories told to them by their elders. CRT and LatCrit can be a tool for teachers to help students move beyond the limitations of hegemony (Delgado-Bernal, 2002; Valdes, 1996).

In the next section, I will turn to those old pseudoscience theories that, based on my students’ comments over the years, I assumed could have remnants in science teaching and learning today. I believe that we cannot refuse to visit the past no matter
how painful. The past informs the present, and it is through acknowledging the past that we can correct the present to improve the future.

**Eugenics**

The focus of this tale—the eugenics era, which prevailed in the early to mid-twentieth century—is to see if such stale history has any effect on the education of students of color today. Eugenics can be defined as follows: the movement devoted to improving the human species by controlling heredity. The word comes from the Greek word *eugenēs*, meaning *wellborn* (Lambardo, 2011; Washington, 2006). The term eugenics was coined by a man called Sir Francis Galton, who was a cousin of Charles Darwin. From 1900 through 1910, he created what was called the Galton Society (Selden, 1999). During the eugenics era those who were involved in it investigated the heredity of people to find out who carried what they hypothesized to be *inferior blood* in an attempt to segregate them, by all means necessary, in order to protect those they hypothesized to carry *superior blood*. (The latter was also called the Nordic group/race. See Selden, 1999, & Washington, 2006.)

Eugenicists believed that all human characteristics were inherited and that the environment played no role in shaping human characteristics. This is puzzling, because some of eugenicists were well-educated individuals who followed important vocations. To mention some of these individuals, I start with “Rough Rider” Theodore Roosevelt, the 26th U.S. president, and his family, and Leta Hollingsworth (1886–1939), a pioneering psychologist. J. Franklin Bobbitt (1876–1956), a writer, university professor, and noted curriculum specialist, was what they called a practical eugenicist; that is, one who believed that only children of sound and sane parentage should be born, and that was
to end problems of child education. He imagined a utopian future in the millennium, equated to the Sun, a Spiritual Republic, built by these children born of perfect parentage.

Robert Yerkes (1876–1956) was an American psychologist, ethologist, and primatologist. He is best known for his work on intelligence testing (see Selden, 1999). Granville Stanley Hall (1846–1924) was a pioneer American psychologist, an educator in childhood development, and an evolutionary theorist. W. W. Charters (1875–1952) was Canadian-born, but lived and worked in the United States. He was a curriculum developer who worked at different universities that included the University of Illinois and the University of Chicago. Karl Pearson (1857–1936) was an English mathematician and biostatistician. And lastly but not least, Edward Lee Thorndike (1874–1949) was a psychologist at the Columbia University teachers college. He supported selective breeding and conducted intelligence testing (see Selden, 1999; and Wikipedia). An individual by the name of David Starr Jordan was the president of the American Breeders Association (ABA)—a eugenics organization—in 1908 (see Seldon, 1999). He and the members of this group influenced all sectors of society, including the courts. They wanted restrictions on immigration and segregation of those they deemed socially unfit (see, Washington, 2006).

Eugenics originated in England in the early 1880s and 1890s. The central belief of eugenicists was that leadership was a natural born quality, i.e., that some people were born with such hereditary qualities that would make them rulers. The rest were to be ruled if they were deemed fit; otherwise, every effort at the disposal of the rulers was to be utilized to dispose the unfit. How? Many methods were used, such as restricting their
procreation by sterilization to effect extermination. Why? To safeguard against their ability to pass on their inferior genes to become a burden to the rest of the society (Galton 1883, as cited in Selden, 1999, & Washington, 2006). The eugenics movement crossed the Atlantic by the late 1890s. Eugenicists rejected environmental policies on human improvement because this would divert their intentions, which were to exterminate those deemed unfit (Cravens, 1978, cited in Selden, 1999).

The American Breeders Association (ABA) established in 1903, adopted Mendelian genetics studies of garden peas to apply to humans. Gregor Mendel (1822–1884) is considered the father of genetics. He was an Austrian monk who loved gardening. He grew peas and, through thorough observations and record keeping, he discovered that different “factors,” as he called them (they were later called “traits”) tended to appear in succeeding generations and mask other factors in the first generation. Once he inbred the offspring of the first generation he was surprised to see those factors that were masked reappearing. He called those factors that were always physically observed (phenotypes) even when only one parent carried them “dominant.” and those that were masked unless both parents carried them “recessive.” These terms have been used in biology ever since. That is, it is common practice for people to say that someone carries a rare recessive gene.

The problem of applying Mendelian framework to humans, though, is that peas and human beings are very different species. There are, indeed, a few genes in humans that have been studied for a long time that show dominance/recessive inheritance patterns, but inheritance in humans is much more complicated than in peas. Mendel’s pea studies were definitely a breakthrough, and they gave way to modern genetics studies.
Mendelian inheritance is a basic unit in the high school biology textbooks of all major publishers (for example, Glencoe/ McGraw Hill; McDougal; Prentice Hall; Holt Rinehart Winston; Harcourt Brace). Selden (1999) and Washington (2006) are among those who contend that eugenicists took Mendel’s work and ran with it to apply to human inheritance as a stamp of approval to justify their racial ideologies.

Charles Benedict Davenport, a eugenicist who was the director of the American Breeders Association’s eugenics section in the early 1900s, believed that human characteristics and conditions such as laziness, a love to travel, poverty, and prostitution were traits humans passed on genetically from parents to offspring. Around 1917, the ABA petitioned the Carnegie Institute for $34,250 for human genetics research focusing on superior blood v. inferior blood, with the goal of applying their findings to eliminate the defective germ plasm (see Selden, 1999; Washington, 2006). There were individuals such as C. P. Punnett who warned the ABA against applying Mendelian genetics principles to humans (Punnett 1917, as cited in Seldon, 1999 and Washington, 2006). Punnett was an English geneticist who is credited with engineering the mathematical probability of offspring’ traits from different crosses of parental genotypes. This probability method, called Punnett squares, is used to find the percentage of probability from four offspring to inherit a trait from a single-trait parental cross (monohybrid crosses) or 16 offspring in the case of two traits from each parent (dihybrid crosses). Other individuals like Jacob Riis, a social worker and an environmental reformer, argued that people are good at birth and made to be bad by their environmental treatments (Riis 1914, cited in Selden, 1999). Booker T. Washington (1914, cited in Selden, 1999, and Washington, 2006) expressed his fear that efforts to achieve the goal of halting
population growth being promoted by eugenicist Karl Pearson might be pursued via the lynching and burning of African Americans. Despite the efforts of those who warned against eugenics, its ideology ended up being published in high school biology textbooks, and students were being taught this pseudoscience (Selden, 1999).

Psychologist Adolphus Miller and John H. Kellogg, president of the American Eugenics Society (AES), recommended that a competition be held annually for good health and stamina, with prizes given to winning families. They also recommended the creation of a eugenics registry office that would keep systematic records of winners, among other data (Kellogg, 1914, cited in Selden, 1999). German and American eugenicists were united by the International Society for Racial Hygiene, and particularly by the influence of eugenicists such as the mathematician and biologist Charles Davenport, PhD, who established the Station for Experimental Evolution (SEE). By 1910 the privately funded and influential Eugenics Registry Office (ERO) at Cold Spring Harbor in Long Island, New York, joined with the SEE under the sponsorship of the Carnegie Institute (see Washington, 2006).

Human capital social theorist Herbert Spencer (1940, cited in Patterson, 2005) was among the group that formed the Race Betterment Foundation (RBF). Misusing Darwin’s theory of evolution by natural selection, members of this group believed in the natural selection of man (Popenoe, 1915, cited in Selden, 1999). Spencer is believed to have coined the phrase survival of the fittest, not Darwin, who is sometimes credited for it in biology textbooks. Using this belief, it followed that if a person or persons died prematurely because of poor health, that would denote that they were unfit and that nature had taken its course. These individuals had similar beliefs even about infant
mortality. Kellogg believed that with eugenics methods they could breed humans to produce a new species of humans in six generations (Selden, 1999).

Eugenicists did not seem to care about the fate of anybody who was not of the Nordic race. This was the only group they wanted to protect. Immigrants like the Slovaks, Syrians, Croatians, Dalmatians (Albanians), Jews, Sicilians, and Armenians were considered to be of low human ranks, and eugenicists advocated for sterilization legislation to be applied to them (Pickens, 1963, cited in Selden, 1999; James, 1944). Franklin Bobbitt, known as a practical eugenicist, (Selden, 1999) believed that the strong and capable students should be motivated and the weak be left at the bottom, never to mix with the strong and capable. With his belief, he went as far as advocating for abolishment of public schools, because public schools were supposedly supporting mediocrity (Selden, 1999). Eugenicists disparaged several kinds of people, but no one was as disparaged as a Black person. Davenport, mentioned above, believed that skin color was linked to moral and mental qualities and that they were inherited. Therefore education was not going to do much for Black people. He was also very regretful he hadn’t had the opportunity to burn Jews (Selden, 1999), another group of people he denigrated.

This was also the period when testing started. First it was the Alpha/Beta tests used during army recruiting for the First World War. The tests were created by Robert Yerkes (1876-1956), who was mentioned earlier, with others, and he and Carl C. Brigham (1890–1943) administered the testing program. The preface for Brigham’s book A Study of American Intelligence, published in 1923, was written by Yerkes. In his book, Brigham analyzed several army mental tests and proclaimed that native born Americans
had the intellectual superiority of the Nordic Race over the Alpine (Eastern European) and Mediterranean races. He warned that immigration of these inferior groups should be halted lest they destroy the Nordics. Nothing troubled him more than the lingering thought of miscegenation between Blacks and Whites, as he believed that Negroes were undoubtedly the most intellectually inferior race of all. But by 1930 he had changed his views and disowned his textbook. By that time the Alpha/Beta tests and how they were administered and analyzed had been discredited. Brigham had been the chairman of the College Board from 1923 to 1926, and by 1930 had assumed a new profession—as creator of the Scholastic Aptitude Test (SAT). But the influence of his earlier ideas was being felt. For instance, Harry H. Laughlin (1880–1943), superintendent of the ERO, was able to convince Congress to pass the National Origins Act, which was signed into law by President Coolidge in 1924. This law barred immigrants from Eastern European countries as dysgenic ([of bad origin] Guyer, 1916).

In 1929, when the country was in deep depression, the eugenicists’ argument was that the Depression would select the unemployed for extermination, and the employed for procreation (Osborn, 1934, as cited in Selden, 1999). While eugenicists were busy collecting and conducting racial examinations of Black and White fetuses to compare physical features and other traits they claimed to be so different, some other eugenicists were starting to listen to the opposition. H. S. Jennings, a zoologist, had published a book called The Biological Basis of Human Nature (Jennings, 1930, cited in Mehler, 1988). He argued that once the social and environmental conditions were improved, then it would be possible to determine what the defective genes were and what they do. The eugenicists would not accept such arguments because they felt that improved social and
environmental conditions would improve the survival rate of the unfit, something they were against—they believed in survival of the fittest, not the unfit (Patterson, 2005). Eugenicists were able to infiltrate the National Education Association (NEA). In 1917, Dr. Helen Putnam, a physician and educator, received money from an anonymous donor, which she used to train teachers to teach eugenics in schools. Also, the Committee on Racial Well-being had access to NEA facilities to hold their meetings (Selden, 1999).

One of the people who were against eugenics was Walter Lippmann (cited in Selden, 1999), who wondered how people could talk about intelligence tests before they even knew the definition of intelligence. Lippmann (1889–1974), an American journalist and political commentator during the Cold War, is credited for coining the word stereotype as is meant in modern psychology. He wrote a book titled Public Opinion, which was published in 1922 (see online free encyclopedia Wikipedia). Dobzhansky and Montagu (1947) argued that human inheritance is too complex to be described by single discrete factors, as eugenicists claimed, and they also claimed that both the genes and environment were involved in shaping human characteristics. Another opponent of eugenics was Gould (1981), who expressed his understanding of the eugenics movement as a group of individuals who were categorizing and compartmentalizing people in an effort to keep the existing social, institutional, and political relations unchanged—benefitting only the few (eugenicists). Selden (1999) mentions that among those opposed to the ideas of eugenics were Conn (1914), Montagu (1942), and Morgan (1915), as well as John Dewey.

Some individuals within the eugenics movement began changing their positions back and forth. Once more, studies were being done by scientists with results suggesting
that both genes and environment were working together to shape inheritance. By the mid-1930s, regular people in the society were questioning the eugenics movement, and it was slowly losing ground. Then once the Carnegie Institute withdrew its support in the late 1930s, the end of eugenics was near (Selden, 1999). We should not forget that the quintessence of eugenics was the Holocaust. Because of the National Origins Act President Coolidge signed into law in 1924, when the groups not favored to immigrate to the United States, including the Jews, sensed something terrible (holocaust) was coming their way, they could not immigrate to the United States to escape it. The Holocaust will not be forgotten. Some people might be disgusted to read what I just wrote, but are such ideologies gone? People still have a lot of questions about issues around the inheritance of traits in humans, but might choose ideology over facts—science facts. It was not too long ago when Herrnstein and Murray’s Bell Curve was published (1994), which was going back to the same old theories of racial differences in intelligence and claiming that IQ differences are due to genetics only. The difference this time was that society got up in arms about this publication, and the people and the media spoke against it (e.g., Jacoby & Glauberman, 1995; Jacobs, 1999; Keita, 2001; Passell, 1994).

Some might ask, what has eugenics got to do with students’ interest in science? The discussion of eugenics is important for the current study because, as mentioned earlier, the students in question are students of color, and these students have mentioned certain things to me, their teacher, that made me think they know about these old theories, and it is important to find out if this past, however false it might have been, might be affecting students today, almost a century later. Eugenics was a stereotype-loaded ideology and, there is evidence that recurring stereotyping of African Americans and
other minorities in our society is affecting students of color to the extent that it is interfering with their learning (Nguyen & Ryan, 2008; Schmader & Johns, 2003; Steele & Aronson, 1995; Walton & Cohen, 2003).

Given racial relations in American society in the past, stereotype threat may at least partially account for the loss of interest in learning, in science in particular. It is easy for involved stakeholders, particularly educators, to think that they have done all they can to improve students’ education, but unfortunately, it seems like only the surface of the iceberg has so far been scratched. T. L. Friedman, in his book *The World Is Flat* (2005), says that as the world is getting flatter, our education system is becoming an ever-growing mountain. As the eugenics tale concludes, we are reminded that education of our children is a meandering path with a lot of hurdles to jump. In his theory of localizing powers, John Fiske, formerly a professor in the Department of Communication Arts at the University of Wisconsin-Madison, reminds us about the history. He says,

> The relationship between race and class in the United States may be a sorry story: The roots lie in: slavery for African Americans, in conquest to the point of near genocide for Native Americans, and in economic colonialism for most Latinos. Slavery, genocide, and colonialism are all products of white imperialization. (Fiske, 1993, p. 38)

As I move on to address more of my assumptions as to why my students have demonstrated little interest in science, the next is *stereotype threat*, which was mentioned in the eugenics tale above. I wonder if eugenics is not the root cause of stereotypes.
Other Causal Factors

Stereotype Threat

I assume that stereotype threat, a topic investigated by a number of scholars (e.g., Aronson, 2002; Fischer, 2010; Nguyen, O’Neal & Ryan, 2003; Schamader & Johns, 2003; Steele & Aronson, 1995; Steele, 1997; Steele & Aronson, 2004), could be one of the factors that affect students of color with regard to science. Stereotype threat is a predicament, an interference, that individuals of minority groups deal with as they fear that they might say or do something that would confirm a stereotype others hold against them as a group. It is a burden that individuals guard against as a way to protect themselves and to protect the group from which they belong, because they feel they are never judged as individuals but as representatives of a stereotypical group. Stereotype threat is a constant reminder to one’s position in a society that operates on inequities and injustices. (See, for example, Nguyen, O’Neal & Ryan, 2003; Steele & Aronson, 2004).

Stereotype threat can be a problem in schools if left unchecked. The researchers mentioned above have found that students’ learning can be hindered by cultural stereotypes based on how the society sees their ethnic group. For example, students may choose not to participate in class for fear that they might confirm a stereotype if they do not get the right answer (see, for example, Aronson, 2002; Fischer, 2010; Steele, 1997).

To clarify stereotype threat, the National Longitudinal Survey of Freshmen (NLSF) was conducted by Fischer (2010) of minority students at elite colleges. She found that stereotype threat and a racially motivated hostile climate on college campuses were the major reasons for unequal college graduation outcomes. The survey involved 4,000 freshmen (998 Whites, 959 Latinos, 992 Asians and 1,051 African Americans). It showed
that 75% of the White and Asian students graduated in four years compared to 67% of Latinos and 58% of African Americans. Even though stereotype threat affects minority groups the most, it can affect any group, even a majority. Steel and Aronson (1995) confirmed that White students performed poorly on an exam after they were told that Asian students were going to outperform them. So, all groups of people can be affected negatively by stereotypes. In this example, White students, whose stereotype is that they perform better than others, found themselves, in this case, victims of stereotype threat, a concept supported by Nguyen, O’Neal & Ryan (2003); Ryan & Ryan (2005); Schmader & Johns (2003).

**Role Models and Family Influences**

Another assumption is a lack of role models for African American students. From my research I learned that students tend to do well in school and in science if they have role models in science (e.g., Archer et al., 2012; Codjoe, 2007; McCormic, Capella, O’Connor, & McClowry, 2013; Milward et al., 2006; Pollard et al., 2003). These researchers claim that parents are the most important role models for their children, both directly and indirectly. They explain that parents influence their children’s performance in school by showing interest in what their children do on a daily basis, what subjects they take, and even their future career choices.

These researchers added that students are also influenced by relatives, extended family, and friends of their families who socialize around them and explain what they do for a living; that influences young people in what they study and the career choices they make. Uitto, Juuti, Lavonen and Meisalo (2006) proposed that activities students engage in outside of school enhance their interest. Examples of outside activities include, but are
not limited to, visiting scientific institutions like museums, planetariums, aquaria, zoos, and even libraries. These activities are particularly meaningful when students visit such places with parents or significant adults who engage them in discussions of what they see (Coppola & Pearson, 1998; Eccles & Harold, 1993; Keeves, 1975). I will discuss two studies, by Codjoe and by Uitto et al. that emphasize the importance of the home environment and out-of-school activities. And further discuss other studies that are relevant to my assumptions as to why students might develop little interest in science.

Codjoe (2007) conducted an in-depth individual interviews and group interviews with 12 Black students in Alberta, Canada. He wanted to dispel the stereotypes held against Black students—that they are loud, depraved, lazy, dangerous, criminals, athletic, and deviant. His sample was not random because of the nature of the study. Alberta, unlike other parts of Canada such as Toronto, Halifax, or Montreal, does not have a large population of Blacks, he said. Following the wisdom of other researchers like Nieto (2004), he felt that to get authentic information on the academic success of Black students he would need to be selective and choose those students who had beaten the odds against academic success. So, he recruited, for the study, four youths born in continental Africa, four born in the Caribbean, and four born in Canada.

Even though Codjoe did not say how many of the study group were boys and how many were girls, it was clear from the pronouns used in his article that there were six boys and six girls. He also did not mention the age of the students, he only identified them as “youths.” From reading their stories, I suspect they were high school students. These 12 young people had one thing in common—their academic success. Codjoe conducted one-hour, semi-structured interviews with each individual, and then used the
results of these interviews as prompts for the focus group to develop a dialogue among the participants. These 12 young people were very clear about the Canadian society, and had had firsthand experiences with issues of race, hostility towards Black students in schools, high dropout rates among Black students, low expectations from teachers, and the high enrollment of Black students in nonacademic programs. They were able to share the exceptional ways that had led them to succeed despite the odds leveled against them.

The most important finding of Codjoe’s study was that all the youths credited the homes they came from, the parental involvement, encouragement, and support for their education. They mentioned that they started their academic journey from home long before they entered school. They all mentioned that they were good readers by the time they started school, and one girl said that she had to skip grade seven: she had excelled too much for the school to keep her in grade seven, so she went from grade six to eight. These youths’ stories sounded like they had all come from the same household. The parents assisted them with homework upon arrival from school; the parents taught them about Black dignitaries in North America and about their histories in Africa, the Caribbean, and Canada. Whenever they complained about the name calling they experienced in school because of who they were, their parents told them stories of Black people who suffered unthinkably, people like Paul Robeson, W. E. B. DuBois, and Sojourner Truth, and instilled a sense of pride and self-confidence in them.

These youths were trained by their parents on how to deal and cope with discrimination and racism, and how to avoid letting these negative aspects of society hold them back. The parents did not just discuss these issues with their children, but demonstrated to their children their stand on certain issues. One young man reported that
his school practiced what he called “slavery days” (p. 149) whereby the ceremony would include auctioning students who were “slaves” (p. 149). He said that his mother sent what he called an “extremely polite” but “really nice” letter to the school to warn against the practices of the ceremony. Another young person mentioned that when his family first arrived in Alberta, there was another family that had also recently moved in. His sister and a boy from the other family were registered for grade one. Unfortunately they were both placed in a remedial class. His mother challenged that placement, but the school informed her that the two children were placed according to their ability. The mother took her daughter to be tested, and she was found to have above-average intelligence. Armed with that evidence, the mother demanded a placement change for her daughter, which was granted.

These families made sure that their children grew up with academic materials—books, magazines, newspapers, even comic books. One young man mentioned that he got his interest in science from reading comic books. They all reported visiting libraries frequently in school and out of school. Another important aspect of Codjoe’s study was the social class to which the families of these young people belonged. Their parents were all employed as successful professionals, managers, or technical professionals. These parents taught their children how to advocate for themselves, how to speak to professionals, and how to do all that while respecting authority figures. Basically, these children grew up in a middle-class lifestyle and followed middle-class mores regardless of their race. Their parents trained them how to act in the presence of adverse racial situations.
Class and How Children Are Raised

Annette Lareau wrote a book (2003) about how families in two socioeconomic classes—the middle class and the working class—raise their children. Lareau’s book is chosen here to show how the class an individual belongs to might give them an advantage or disadvantage in life. Her book was reviewed by Pearce (2004). Pearce concisely explained how the achievement gap between middle-class and working-class children develops regardless of race. This study corroborates Codjoe’s (2007) Canadian study discussed above. For more than a year, Lareau observed nine- and ten-year-olds at two elementary schools and 12 of these children at their homes. She interviewed 88 parents of these children, and observed class inequalities in their children at an early age. She constructed two approaches to show how these two classes raise their children: what she called concerted cultivation by the middle-class parents and what she called natural accomplishment of growth applied by the working-class parents. These two methods of rearing children are discussed herein.

The middle-class parents nurtured their children’s talents by organizing daily activities tailored to the individual child. They also fostered their children’s reasoning skills as they intervened on their children’s behalf with teachers, coaches, and other significant persons in children’s lives. The children were taught to shake hands and look adults in the eye. They challenged their children on how to ask questions intelligently and on what they will ask doctors and other service providers, and in this way they built vocabulary for what to say and to whom. These children learned early on how to request services they wanted. These learned skills taken together prepared them to achieve within
social institutions like schools and later on in life. Pearce identified only minor shortcomings in this style of rearing children, which is that since siblings had independent activities, once they finally got together they fought a lot. They were exhausted and stressed out at the end of their daily routines and barely had any patience with one another.

This particular middle-class way of raising children mirrors what Codjoe’s study group shared with him. I recalled reading in Codjoe’s paper about one youth who explained a situation where she was minding her own business when someone in the community recognized her and asked if she were a daughter of a physician, who was her father. When she confirmed it, she was surprised at what she heard of how good her father was as a physician. With that, she realized she needed to hold her head high. Another youth in the group spoke about children who are taught to only be seen but not heard, and gave the opinion that it was wrong, that children should be taught how and when to speak and to speak respectfully and eloquently. It was quite clear that those were the mores of the middle class regardless of race or ethnic group.

Returning to Pearce, the working-class families’ rearing style was spontaneous, geared towards meeting their everyday basic needs. The talents were allowed to develop naturally around and near the home where their activities took place. They had fewer structured activities but interacted with siblings more regularly (than the middle-class children did). The children played together and they made things, allowing their imaginations to develop. Parents taught their children clear boundaries between adults and children, where obedience in the presence of adults was adhered to. These parents’ modelled uneasiness and restraints when interacting with school officials, authority
figures, and other professionals. The children in this class category were raised to accept things as presented to them, with no demands or challenges allowed. The advantage these children had over the middle-class children was that they did not display any stress or fight amongst themselves.

The only minor criticism Pearce raised against Lareau’s work was race. She wondered how Black parents in each class taught their children how to deal with racism, since class does not in itself shelter anyone from racism. Judging from Codjoe’s account of race, I would think that in each group the parents taught their children how to cope with racism in their own way, just as they taught them everything else. I deduce such an assumption from how the young people in Codjoe’s study described their parents’ tactics for dealing with racism. So, it is possible that the middle-class Black parents might have had better tools to deal with issues of racism compared to the working-class Black parents. Or it may be the other way around. But they must have taught their children nonetheless.

**Exposure to Out-of-School Activities**

The next study, by Uitto et al. (2006), addressed gender differences in and out of school science experiences and whether or not there was a correlation between interest in science and extra-curricular experiences. The study was done in Finland with high school biology students ($N = 3,626$), with an average age of 15. They used the *International Relevance Of Science Education* (ROSE) survey questionnaires on eight interest-context factors and seven out-of-school experience factors to answer two of their research questions: (1) Are there any gender differences with regard to the interest and the out-of-school activities? (2) Is there any correlation between pupils’ interest in biology and their
out-of-school experiences? The surveys consisted of 108 statements on interest in science and 61 statements on out-of-school activities. They used SPSS multivariate analysis and stepwise explorative factor analysis. The results revealed that out-of-school experience related to nature, technology related activities, activities which involved the use of science kits, and constructing models were the most important factor correlating with interest in biology. Gender wise, the study showed that girls’ interests were in human biology and health education, such as exercising, healthy eating, or eating disorders; while boys’ interests were in basic processes of biology such as ecological and cellular phenomena. Gender differences in applied biology, zoology, sexuality, genetics, and evolution were minimal.

These last three studies, by Codjoe, Lareau, and Uitto et al., have clearly shown that students’ academic success is well enhanced by what happens at home; and also that science need out-of-school catalysts to enhance interest.

Science vs. Scientists

The next study to be discussed was conducted in the United States, in Northern Illinois school districts. It focused on attitudes towards science and about science. Kitts (2009) studied middle and high school students’ attitudes towards science versus their attitudes about science as a career. Kitts used 86 preservice teachers to survey 2,535 students in 27 rural, suburban, and urban school districts. The preservice teachers’ categories were: 50% seeking biology certification; 25% geology certification; 15% chemistry certification; and 10% physics certification. Student categories were: 50% (grades 6–8) and 50% (grades 9–12). The study involved 10 questions (see Table 2.1) about students’ interest in science, their attitudes about scientists, their confidence in
science and scientists, and desire to do science, as measured on a 10-point Likert scale whereby 10 represented “absolutely agree” and one, “absolutely disagree.” Kitts explained that she got the questions from a quantitative affective domain instrument that was developed by the University of Nebraska-Lincoln in collaboration with her institution, Northern Illinois University, and that the study was partly funded by a National Science Foundation (NSF) GeoEd collaborative grant.

Kitts was investigating the results of efforts that have been made in the Northern Illinois area to encourage students to study science and to enter science related careers. The 10 questions of the instrument were divided in such a way that they would target the areas of her research: general interest in science (questions 1 and 3); opportunity (questions 2, 4, and 6); cultural stereotypes (questions 2, 4, 7, 8, and 9); science pedagogy (1 and 6); perceived competency in science (4, 6, and 7); desire to enter science work (question 3); teacher bias (4 and 7); mentors/role models (question 5); and familial support (question 10). The data collected included a students’ age, grade level, and sex; race was left blank, optional for students to fill in if they chose. The preservice teachers identified each student’s class, grade level, school, and district. They encoded aggregated data and analyzed them with various statistical methods, including a student’s t test.

The categories to be compared included: (1) male/female, (2) school district (rural, urban, or suburban), (3) middle school, (4) high school, (5) race. They wanted to see if there were a statistically significant differences in the average means of students’ responses under the five categories. The results showed no statistically significant difference in the student t test (p ≤0.05 confidence level) among the categories. Sixty
percent of students identified their race, but the percentage was not found to show any significance for the study.

Table 2.1. (K. Kitts, 2009)
*Science Attitudes Survey Questions*

<table>
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<th>Question</th>
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<tr>
<td>I think science is really interesting.</td>
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<tr>
<td>Scientists are mostly men who wear white lab coats.</td>
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<tr>
<td>I might want to be a scientist.</td>
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<tr>
<td>Science is too hard for me.</td>
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<tr>
<td>I know a scientist personally.</td>
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<tr>
<td>You cannot do science without knowing lots of math.</td>
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<tr>
<td>Girls aren’t good at science.</td>
</tr>
<tr>
<td>Scientists can’t be trusted.</td>
</tr>
<tr>
<td>Scientists can’t be religious</td>
</tr>
<tr>
<td>My family would be proud of me if I became a scientist.</td>
</tr>
</tbody>
</table>

The findings of the study showed that the students no longer held stereotypes about scientists such as that girls cannot do science, that scientists are these males wearing white lab coats, that scientists are untrustworthy and irreligious. All of these students’ responses were echoed by Chambers (1983). Students responded that science was interesting and that their parents would be proud of them if they were to become scientists. However, very few students indicated that they might want to become scientists; this aspect is supported by Jenkins (2003, 2006, 2007, & 2009) and Jenkins and Nelson (2005).

Students were neutral on question four and question six, on whether science was too hard or that they would need a lot of math to do science. They did not think they knew a scientist at a personal level, from which it can be assumed that students did not see their science teachers as scientists. Following this response, Kitts (2009) did not think the students clearly knew the definition of a scientist. This seemed to point to a lack of role models, according to Kitts, and that opinion is supported by Hill and Craft (2003),
Furthermore, the fact that these students reported that their families would be proud of them had they chosen to pursue careers in science but then failed to identify a scientist they knew at a personal level, and the fact that they were interested in science but not in being scientists, point to the students’ not having close science role models (Archer et al., 2012; Coppola & Pearson, 1998; Eccles, 1993; Hill & Craft, 2003; Hill & Taylor, 2004; Keeves, 1975; White & Harrison, 2012).

Kitts encourages future studies that will prod students to find out why they don’t want to be scientists. She also recommends that educators make students aware of STEM education and that there are funds from NSF and NASA, particularly in physical sciences. Geoscience has the lowest number of graduating scientists than any other STEM field; it is an area in which interested minorities and women have a chance of having their education paid for by NSF and NASA. Secondly, the myth about math as a prerequisite for science, which results in high levels of anxiety, should be dispelled. The level of math needed to do science—especially at high school and undergraduate levels—is basic, and many students can do it. The following study also focused on students’ interest in science.

**Children’s Perceptions of Science: The Murphy and Beggs Study (2003)**

These two researchers looked at children’ perceptions of school science. These were 8- to 11-year-old-children who showed a progressive decline in their enjoyment of school science. The researchers investigated whether students’ interest in science starts to decline in the final years of elementary school as reported in research literature. See, for
example, Ainley, Hidi, and Bergdorf, (2002), Hewitt and Seymour, (1997); Archer et al., (2010); and Ebenezer and Zoller, (1993), who claimed that a decline starts between ages 9 and 14. The questionnaires used by Murphy and Beggs contained items ranging from students’ favorite science topics and their attitudes toward science to students’ and teachers’ classroom conversations about science. This study took place in Northern Ireland. Out of 1,000 students, 50.1% were girls and 49.9% were boys, and these percentages approached the country’s population (49.3% women, and 50.7% men). Age-wise, 57% were eight to nine years old, and 43% 10 to 11.

In November 2000, students completed the questionnaires, and 32 selected students were involved in informal discussion with their classroom teacher. Those 32 were chosen based on gender, age and ability. Two students came from each class out of the 12 schools that participated. The group of 32 completed their portion of the study in February 2001. It included a simple three-point scale (“yes,” “not sure,” or “no”), and for the science-related topics, students indicated their choices by a check mark for “like” or “don’t like.” For the free response questions, students wrote down what they expected science lessons to be like in secondary school.

The findings showed that the older the students got the less interest in science they became. Students expressed frustration with certain topics, such as “parts of a flower” and “evaporation” because of the complexity of the terminology. As for attitudes, the researchers found that, based on student pretest and post-test results, girls held more positive attitudes compared to boys, with the girls’ mean scores significantly higher than the boys’. They also reported having observed the excitement girls portrayed throughout the study—their participation and comments they made that supported the claim that the
girls’ attitudes were more positive than the boys’. Of the 16 science topics that are commonly taught in primary schools, boys indicated preference for physical sciences and girls for life sciences. A majority preferred lessons that included experiments over those that involved taking notes and listening to lectures. The majority reported that preparing for tests was the most boring activity because of its repetitiveness and memorization. Of the eight/nine age group, 57% reported receiving help with homework, and 41% of this group reported that they sometimes watched science or nature programs on television. This activity category (watching nature shows on television) was also reported by 24% of the 10/11 age group.

Finally, the researchers of this study noted that there were problems with the age ten/eleven physical science curriculum for both the teachers and the students. Their recommendations were that teachers must have adequate content knowledge about what they teach. The authors’ recommendation for primary school science teachers was to focus on observations and descriptions of phenomena for the young children and to leave the explanations for post-primary. In life science, for example, they suggested a focus on the lives of plants and animals to stimulate interest and curiosity rather than having students memorize incomprehensible flower parts (e.g., ovules, scapula, sepals, petals). The new U.S. science standards—NGSS—also emphasize avoiding rote learning (National Research Council, 2011; Sneider, Stephenson, Schafer, & Flick, 2014).

The Role of Motivation in Learning

Two motivational factors, interest and goals, are known to influence a person’s academic performance (Hidi & Harackiewicz, 2000). A model study for cultivating curiosity and interest in science in young children was done by Paris, Yambor, and
Packard (1998) in Michigan under the title Hands-On-Biology: Museum-School-
University Partnership for Enhancing Students’ Interest and Learning Science. The
researchers assessed the effects of a six-week extracurricular science program that
provided college-student docents as part of the classroom resources. The program
included 184 students in grades three, four, and five. The group was comprised of 58
third grade students (29 females and 29 males), 60 fourth graders (31 females and 29
males), and 66 fifth graders (33 females and 33 males). There were three classes per
grade. The majority of students were Caucasian ($N = 103$), 27 students were African
American, 41 were Asian American, and 13 were from other ethnic groups. There were
no analyses conducted by ethnicity because of a wide diversity within each general
group. Some students were recent arrivals to the United States, and some did not speak
English. Ninety-two students (50%) were enrolled in English as a second language (ESL)
classes. Some students had mixed ethnicity, and these were unevenly distributed across
genders and grades. The majority of students were from low-income households.

An attitudes survey and a test of scientific problem-solving were conducted
before and after the project, finding a significant improvement in students’ problem-
solving skills at all grade levels. Girls showed more positive attitudes about what they
were doing and had higher problem-solving scores than boys. Case studies of a
subsample of 18 students revealed that most of these students were highly motivated to
use the docents, peers, and classroom resources to create their individual projects, which
they showcased at a family night that had good parent attendance. Follow-up interviews
with three of the students’ teachers added further support for the benefits of this
intervention.
In this study, the third graders were more enthusiastic than fourth graders and fifth graders, showing that the level of interest decreased as the children’s age increased. This aspect is also reported by other researchers (e.g., Renninger, Hidi, & Krapp, 1992; Schiefel, Krapp, & Winteler, 1992; Shirley & Reynolds, 1988). According to the authors, the interest that the children portrayed will need to be enhanced throughout their elementary, middle, and high school years. Studies have shown that by the time girls finish high school and go on to college their enrollment in science and science-related fields diminishes (Baker & Leary, 1995; Catsambis, 1995; Jayaratne, Thomas, & Trautmann, 2003; Kahle & Meece, 1994; Packard & Wong, 1999; Weingburgh & Steele, 2000). Since gender differences begin to appear early, this study advocates for more science laboratory opportunities for children throughout elementary school. Others have added that there should be a balance between activity and skills of participants in science to enrich learning and interest (see, for example, Csikzentmihalyi, 1975). Additional studies have offered similar recommendations to keep students interested in science from grade school forward (Osborne & Collins, 2003; Osborne & Dillon, 2008) and saying that without such approaches the participating students would have excluded science in their future beyond mandatory high school graduation requirements. (Tai, Qi Liu, Maltese, & Fan, 2006; Osborne & Dillon, 2008).

**Interest and Learning**

A century ago, John Dewey (1913) wrote about the importance of interest and motivation in learning; that is, if the learners are interested in a subject, they will work harder to excel in that subject or a topic of a subject. Dewey admitted that this idea was against the pedagogical practice of the time, because during that period educators thought...
that students’ interest was not to be taken into consideration (Dewey 1916). Educators then thought that if students were working on topics of their own interest they would show no effort, but if they were working on unpleasant topics they would be challenged, and hence would have to discipline themselves and work harder—make an increased effort—to accomplish the task. Dewey’s pedagogy was received with suspicion when first published, but once he put it to work directly with students at the school he founded in Chicago, his philosophy became popular, and by 1925 it was accepted and practiced by other educators.

Dewey believed that methods of children’s learning required freedom to discover things using prior knowledge (Dewey, 1916). Dewey’s life (1859–1952) was dedicated to teacher preparation at the University of Chicago, and his philosophy of education dominated twentieth-century teacher preparation curricula and teaching all over the world (DeBoer, 2000). He advocated for teaching the steps of scientific methods, but not to have students memorize them in the order as listed in many science textbooks and laboratory manuals, but rather to allow students to have freedom to come to their own discoveries through trial and error. In this manner, students would be able to answer their original question in whatever order of functioning they so choose. He believed that schools should afford children the freedom to solve their own social problems. He explained that by allowing students to be involved in activities of their own interests based on past experiences; old experiences will evolve into new experiences and interests, replacing the old ones. He believed that education is the ingredient for equality of opportunity, and that without education; equality of opportunity is nothing but an empty phrase. This idea resonates with Paolo Freire’s letter to teachers in which he said,
“It is true that education is not the ultimate lever for social transformation, but without it transformation cannot occur” (Freire, 2005, p. 69).

While reviewing literature about student interest, I found plenty of studies done on the topic, but mostly by psychologists. According to Krapp (1999) and Krapp, Hidi, and Renninger (1992), interest is content-specific, and that interest is among the things that motivate people to engage in learning behaviors (also see Dewey, 1913). Furthermore, interest is said to have a positive correlation with education outcomes (Krapp, Hidi, & Renninger, 1992), and the outcomes could set apart experts from skilled performers (Hidi & Harackiewicz, 2000). It is important to find out which fields of science students like or dislike, or if it is certain topics within a particular subject. This way some measures can be developed to address the problems by revisiting the curricula to sort out what students like and leave out what they don’t like. A tailored curriculum can be developed to evoke interest and persistence in learning (Ainley, Hidi, & Berndorff, 2002; Harackiewicz, Barron, Durik, Linnenbrink-Garcia, & Tauer, 2008).
I will now discuss the history of science education, its turns and twists over two centuries to date. The history will demonstrate why science, among other disciplines, is and has been part of the American culture.

Teaching science as an inquiry in America began in the early 1800s, but science did not gain recognition until the mid-nineteenth century. Prior to this period, faith was as important as empirical data. All learning was through deep-rooted Christian theology and idealism traditions (DeBoer, 1991; DeBoer & Bybee, 1993; Stedman, 1987). Advancements in physics, chemistry, biology, and astronomy became important during the progress of the Industrial Revolution, which forced America to demand scientific thinking in order to solve everyday problems. A historian, John Rudolph (2002), cited in Tozer, Senese, & Violas, 2009), reported that at around 1884 one scientist reorganized teaching of scientific methods in higher education. This scientist was Louis Agassiz at Harvard University. He was a biologist / zoologist / ichthyologist and geologist who spearheaded the teaching of science as inquiry. Some writers consider him the father of scientific inquiry in America (see, for example, Wikipedia).

Agassiz invited students to his laboratory and allowed them to study his specimens. He took his students on field trips to the countryside and the seashore. He encouraged them to develop their own collections, and he established correspondence with many collectors around the country (Stedman, 1987). Charles W. Eliot, a chemist and president of Harvard University, was another scientist who established laboratory work as part of science instruction (Stedman, 1987). Eliot, for example, incorporated physics laboratory work as part of physics college entrance requirements. The
requirements were published as a descriptive list of elementary physics courses. Thereafter they were accepted by the National Education Association’s Committee of Ten, and eventually they became the first national science standards. The Committee of Ten was the first group to try to standardize K–12 education.

**Earliest Standards: The Committee of Ten**

Laboratory methods moved from broad goals statements to policy recommendations. In the 1893 meeting of the National Education Association, the Committee of Ten reported on the importance of science for all students, not just for those who were going to college. The report won acceptance for what they called the “absolute necessity of laboratory work” (NEA, 1894, p.27) under the supervision of two scientists—college presidents Charles W. Eliot (Harvard) and Ira Remsen (Johns Hopkins). The curriculum was readily accepted by prominent universities’ feeder high schools. However, it was challenged by other high schools with limited resources. High school administrators under the auspices of scientists like C. R. Mann, who had been involved with physics teaching for a long time (e.g., Mann, 1912), and organizations like the Central Association for Science and Mathematics Teaching had reservations about the laboratory requirements; especially the Harvard list of experiments (Isenbarger, 1950). Such groups appealed for a revised Harvard laboratory list to address physics for personal and social relevance that would stress qualitative laboratory work (Rudolph 2002, cited in Tozer, Senese, & Violas, 2009). Later, much later, the United States experienced a rude awakening: Sputnik.
Curricular Reforms: WW II, Sputnik, and the Cold War

Reactions to the Soviet Union’s launch of Sputnik created a need for scientists in the United States (Rudolph 2002, cited in Tozer, Senese, & Violas, 2009). To have the Soviets ahead of the United States in the space race was not only a matter of national security, but pride as well (Rudolph, 2002). Congress passed the National Defense and Education Act (NDEA) in 1958, and President Eisenhower signed it. Prior to the launch of Sputnik, the National Science Foundation (NSF) was funding all research in education and in other areas except health, which was funded by the National Institute of Health (NIH). There was also research taking place concurrently under the U.S. Atomic Energy Commission (nuclear and particle physics).

However, after the launch of Sputnik, the NDEA was enacted to fix education in areas of science, mathematics, and foreign languages to compete with the Soviet Union. At the same time, the National Aeronautics and Space Administration (NASA) was created to deal with the space race as Sputnik anxiety consumed the U.S. society. Under President Eisenhower’s aegis, domestic scientists had to be grown as quickly as was humanly possible. The President’s Science Advisory Committee (PSAC) brought the federal government into science education. Released in 1959, the government publication which was called, *Education for the Age of Science* led a practical national interest in cultivating future scientists (Hurd, 1958). Under PSAC’s directives, a secondary school science curricular reform movement began (Shamos, 1996; Rudolph, 2002, cited in Tozer, Senese, & Violas, 2009).

Paul DeHart Hurd was one of President Eisenhower’s science advisors. He is known for spurring science literacy in Sputnik’s wake (Holton, 1998). Hurd, in his 1958
Science Literacy: Its Meaning for American Schools, cited the influence of science in a modern society, echoing Conant’s bewailing of a lack of science literacy in elementary and secondary curricula. Hurd felt that these curricula had an array of concepts none of which had any depth or coherence with each other. Hurds’ concerns have followed science curricula into the twenty-first century. Thanks to the Next Generation Science Standards, these very concerns are being addressed. In the period from the launch of Sputnik in 1957 to the mid-1960s, science curricula underwent a series of reforms, beginning with what was called the NSF curriculum. (NSF funded the reforms, nicknamed the alphabet soup because of the endless acronyms that would follow.) Among these curricula were the Biological Sciences Curriculum Study (BSCS), the Physical Science Study Committee (PSSC), the Chemical Education Material Study (CHEM-STUDY), and the Earth Sciences Curriculum Study (ESCS), (DeBoer, 1991).

Avoiding what the curricular developers conceived to be anti-intellectual instructional practices of the time, the alphabet soup curricula foci were discipline-specific contents and laboratory skills (Hurd, 1998; Rudolph, 2002, cited in Tozer, Senese & Violas, 2009). The problems were not over yet. There was low enrollment in physics; and hence more reforms were demanded. Harvard Project Physics was born under the auspices of Gerald Holton, a physics professor and a well honored science historian. Holton was joined by James Rutherford, a high school physics teacher, who was, at the time, a Harvard graduate student, and Fletcher Watson, who was a professor of education (Holton, Rutherford, & Watson, 1967). Together they wrote a physics curriculum that accommodated historical contexts in ideas and cultural aspects of science
(Holton, 1969). This curriculum proved successful in terms of enrollment. Female students, particularly, preferred this course over traditional physics courses.

Admiral Hyman Rickover was an influential voice for reform during this period. He was a naval engineer, a nuclear submarine designer, and a technical and scientific educator working with a small, talented, elite group in the wake of Sputnik. He claimed that education was America’s first line of defense (Rickover, 1959, cited in Tozer, Senese, & Violas, 2009). The admiral wanted the elite students to be trained together in a homogeneous European-style secondary school under which academic standards were maintained while slow learners were weeded out so as not to impede the established homogeneity. The gifted/talented students were identified early and put into accelerated educational programs. These efforts were put forth to enhance American freedom, to keep pace with the Soviet Union. The admiral stated that the future belonged to the best educated nation, and he vowed to make that best educated nation the United States (Rickover, 1959, cited in Tozer, Senese, & Violas, 2009). Rickover’s efforts and that of other intellectuals like James B. Conant and John Gardner, who supported meritocracy, were among those who fostered the passing of the National Defense Education Act (NDEA, 1958). And, of course, the rest was history after Neil Armstrong walked on the moon on July 20, 1969, as part of the Apollo 11 project.

The Coleman Report

To fulfill one of the provisions of the Civil Rights Act (1964), James Coleman was commissioned by the U.S. Office of Education to conduct a study of equal educational opportunity for individuals by reasons of race, color, religion, or national origin. Coleman and his team of researchers gathered data on over 6,000,000 school
children, 60,000 teachers, and 4,000 schools across the nation. The following were their findings published in the Coleman Report (Coleman et al., 1966).

Most African American students and White students attended predominantly single-race schools.

“Measurable” characteristics (e.g., physical facilities, curricula, material resources, and teachers) were similar; but measurable performance on standardized tests showed considerable differences, with White students well ahead of African Americans.

The study concluded that educational inputs (facilities, curricula, and teachers) seemed to make no meaningful difference in outcomes (academic achievement). The only variable that seemed to affect educational achievement was quality of peers. Minority children—African Americans, Latinos, Native Americans—entered school with lower achievement scores, and this gap increased throughout their stay in school. Coleman’s study was criticized by a number of educators and researchers (e.g., Carver 1975) who claimed that Coleman used an inappropriate test that was designed for aptitude assessment, but used it to measure achievement instead. Furthermore, some claimed that in Coleman’s study, teachers’ quality was measured by their levels of education and experience alone; in this way the report put the blame directly on the students. The critics felt that the study seemed to expose the weaknesses of students, which would in turn invite scientific investigations of the children rather than of the schools and the larger society.

After that, the Carnegie Foundation sponsored a seminar at Harvard University to examine Coleman’s report. Daniel P. Moynihan and Frederick Mosteller were involved
in analyzing the report’s data. Their findings were published as *On Equality of Educational Opportunity* (Mosteller & Moynihan, 1972). The seminar concluded that America had reached a point of diminishing returns in educational expenditure, and that poor students had themselves to blame for the poor academic achievement rather than societal problems. Therefore, Coleman’s report and Mosteller/Moynihan analysis of his data echoed each other. Christopher Jencks was one of those who agreed with the analyses that unequal achievement was caused by deficiencies in the child, not the school (Jencks et al., 1972 & 1973). Jencks and his colleagues went on to conclude that there was no future economic inequality predictable by family background, schooling, IQ, and cognitive skills. However, they recommended that society spend more money on schools to make them desirable for students, since students spend 20% to 25% of their time in schools.

**The Era of Standards-Based Reform**

The movement toward standards-based education policies is in its fourth decade, with changes being made during the term of each succeeding U.S. president’s leadership.

**President Ronald Reagan (1981–1989).** Standards-based reforms started in the Reagan years, under the president whose electoral campaign promises were, among others, to cut federal spending and possibly abolish the Department of Education (Lewis, 1984), even though the department had already suffered significant cuts by 1981. The Science Education Directorate, a charter of the NSF, which funded educational research, was about to be cut as well (Lewis, 1984). The president requested that his secretary of education, Terrel Bell, initiate the formation in 1981 of an investigative committee, which was named the National Commission on Excellence in Education (NCEE). The
commission was headed by David Pierpont Gardner, who was at the time the president of
the University of Utah and president-elect for the University of California, Berkeley. He
was joined by, among others, Glenn T. Seaborg, a professor of chemistry at the
University of California, Berkeley, and a Nobel laureate. Seaborg had been the chairman
of the CHEM-STUDY curriculum which was used in the sixties and early seventies.
CHEM-STUDY had been a well-documented failure (see, for example, Swartney, 1969),
and had been discontinued in schools by 1967.

The NCEE’s report *A Nation at Risk* (1983) indicated that K–12 educational
achievement was on a downward spiral that would result in jeopardizing the state of U.S.
technological and economic supremacy, the commission’s two major concerns. The
report blamed students, teachers, and parents for their acceptance of mediocrity in
performance. The major claim was that educators and parents demanded nothing above
their students’ comfort; and these attitudes were the reason education was in shambles.
So, rigorous standards for K–12 were recommended in the hope of harvesting the
maximum talents and abilities from being wasted. The *NAR* contributed to the expansion
of the federal government presence in American education.

The government demanded improvement of education for socially and
economically disadvantaged youth. Unfortunately, this became the beginning of
mandated standardized tests to determine students’ achievement. The *Nation at Risk*
report was in high demand across the nation and abroad for the next 12 months. It
received unprecedented media coverage surpassed only by the 1954 U.S. Supreme Court
decision in *Brown v. Board of Education* and the uproar over education in the wake of
the Sputnik launch in 1957. Organizations like the National Council of Teachers of
Mathematics (NCTM) and the National Science Teachers Association (NSTA) were instrumental in providing recommendations and guidance for the creation of curricular standards (see Kliebard, 1987).

**Presidents: George H. W. Bush (1989–1993) and William Jefferson Clinton (1993–2001).** In 1989 president George Bush established the National Educational Goal Panel (Labov, 2006), which was a work in progress throughout his presidency. The panel released a report called *Raising Standards for American Education: A Report to Congress, the Secretary of Education, the National Education Goals Panel, and the American People* (National Council on Education Standards and Testing, 1992)). In conjunction with the previous report *A Nation at Risk*, there were now considerations and possibilities for developing national education standards. Despite the fact that this idea was a sensitive subject politically (Gamoran, 1996); President Clinton was willing to take the risk. Hence, the Department of Education went ahead and pursued federal education standards. Nonetheless, their development remained a work in progress until the end of Clinton’s term.

**President George W. Bush (2001–2009).** The National Educational Goals Panel was replaced by *No Child Left Behind* (NCLB), a congressional act signed into law by the president in 2001. Under the provisions of this act, states were required to develop local standards in reading and math. Once the law was enacted, schools, teachers, and students were held accountable to these standards, and NCLB tied educational funding to students’ achievement (Labov 2006). In 2001, only 36 states had science education standards, but by 2006 all states except Iowa had adopted science standards (Finn, Julian
& Petrilli, 2006; Lerner, 2001). States continued to develop standards for other subjects as time went by until the Bush term ended, but there were no national standards as of yet.

**President Barack Hussein Obama (2009–2017).** The first effort under President Obama was the enactment of the American Recovery and Reinvestment Act ([TARRA], 2009) which authorized the Race to the Top (RttT) program. States would compete for education funds by submitting grant-like proposals. These proposals would include a commitment to adopt the common national standards. Proposals that would focus on specificities of science, technology, engineering, and math (STEM) would fetch more points upon evaluation of their proposals. More points meant more money. Arne Duncan, Secretary of Education, announced that almost $5 billion had been reserved for these proposals. The proposals were to be written out and presented in phases.

In 2010, the National Governor’s Association (NGA) unveiled the Common Core State Standards (CCSS) in English and Mathematics (Carmichael, Martino, Porte-Magee, & Wilson, 2010). The National Research Council’s science education branch prepared the *Conceptual Framework for New Science Education Standards*. Common Core state standards were finalized and published in June 2010. By August 2010, the RttT phase II deadline was due, and states were required to demonstrate implementation of the common core. By July 2013, 43 states, the District of Columbia, four territories, and the Department of Defense Education Activity (DoDEA) had adopted the common core standards. However, assessment instruments for the common core were still in the works, and it was unclear which states would be able to afford the testing because it cost $79.30 per student to complete the entire assessment (Gewertz, 2013b).
Standards for Science

This section will discuss several of the most important focal points of standards development.

**Project 2061.** This project was one of the most productive of the early standards reforms. It was created in 1985 as an initiative of the American Association for the Advancement of Science (AAAS). The project’s name referred to *Halley’s Comet’s* return visit to Earth that will occur in 2061; recalling that the comet passed by Earth in 1985. The communications manager for the program, Sheila Harty, wrote that individuals who were born the same year as Project 2061 would be senior citizens when *Halley’s Comet* return, only by that time they would, it was hoped, be very knowledgeable about science (Harty, 1993). The director and deputy director for the project were James F. Rutherford and Andrew Ahlgren, respectively. They both were members of the Harvard Project Physics talked about earlier. They worked with Gerald Kulm, and together they brought the project to fruition (Holton, 2002).

Project 2061 was organized in three phases, the first of which was an explanation of what students need to know by the time they graduate from high school. The second phase was the creation of tools and exemplary curricula; and the third was the execution of the curricula nationwide (Harty, 1993, summary). The first stage of the project, published under the name *Science for All Americans*, was a summary of what would make all Americans scientifically literate (Rutherford & Ahlgren, 1990). Following this was the publication of an enormous book, *Benchmarks for Science Literacy* (AAAS, 1993). These benchmarks charted science content for students to learn and know by the end of grades two, five, eight, and 12. Project 2061 focused not only on science standards
but on how science could be integrated into other subjects by including standards for mathematics, technology, and the social sciences, as well as history.

In addition to the benchmarks for science, in stage II of the plan the project issued *Blueprints for Reform*, which analyzed studies and recommendations on the importance of education reforms (Holton 2002), followed by *Designs for Science Literacy* (AAAS, 2000), which demonstrated science curriculum design. In 2001 and 2007, the two volumes of the *Atlas of Science Literacy* were published by Project 2061 (AAAS). These volumes outlined and mapped in sequence (using concept maps) what was to be taught, by grade levels.

As Project 2061 was taking root, the National Research Council (NRC) developed and published the National Science Education Standards (NRC, 1996) at the request of the National Science Teachers Association (NSTA). Several events laid the groundwork for the publication. In 1990, the Project on Scope, Sequence, and Coordination to develop standards was initiated by the NSTA with funding from the National Science Foundation (NSF) and the US Department of Education after NSTA had requested the assistance and authority of the NRC in making the project a reality. The National Academy of Sciences (NAS), together with the NRC, then published the standards in a book called *National Science Education Standards* (NRC, 1996). The Benchmarks and NSES creators agreed that the standards document should include the history of science and the nature of science (Rudolph, 2000). The NSES and Benchmarks for Science Literacy have since become the essential science education texts. Recognizing the significance of the history and nature of science. In 2009 the National Assessment of Educational Progress (NAEP) supported and acknowledged the two texts as the best ever published in science.
instruction. The Benchmarks and the NSES were not compulsory for states to adopt: they were published to provide guidance for states and local districts to utilize in drafting their own curricula and instructional strategies. Most states, however, readily adopted them as their standards.

**Science-Technology-Engineering-Mathematics (STEM).** The effort to promote STEM learning is a current and ongoing phenomenon in education that has been weaved into science curricula in the 1990s and 2000s. The National Science Foundation (NSF) has funded a number of projects. Science and mathematics are always part of K–12 curricula, and T-technology and E-engineering have been added to K–12 curricula to encourage and enrich cross-disciplinary subjects in schools (Bybee, 2010; Sanders, 2009). Curricula for K–12 and for high school in particular are criticized by many scholars who are concerned that students are being taught individual subjects as fragments rather than integrated disciplines, when the latter makes learning more realistic (Jenkins, 2009; NRC, 2011). According to these critics, having engineering in K–12 education will enhance problem solving and innovative skills (National Academies’ National Research Council, 2011). The International Technology Education Association (ITEA) played a role in shaping STEM education, and in March 2010 changed its name to read International Technology and Engineering Educators Association (ITEEA). It is the NSF that coined the designation STEM. Among the projects that NSF was funding 1994–2005 is the Technology for All Americans Project (TfAAP), which also receives funds from the National Aeronautics and Space Administration (NASA). Overall, STEM disciplines provide opportunities for certain twenty-first century skills—adaptability,
complex communication, social skills, non-routine problem solving, self-management, self-development, and systems thinking, among others (NRC, 2011).

The U.S. economy and image under threat. It is reported that in 2009 approximately 1.25 million youth left school without high school diplomas, and one third of all graduate students enrolled in the U.S. colleges and universities came from abroad. In 2003, only 4% of college graduates majored in engineering compared to 13% in Europe and 20% in Asia. The Business Roundtable, an association of CEOs of U.S. companies warned in 2005 that if these trends in education were to continue, 90% of all scientists and engineers in the world would come from Asia. The Standards for Technological Literacy (STL), which were written in 2000, 2002, and 2007 by the International Technology Teachers Association (ITEA; now the ITEEA) are geared towards preparing young people with the skills mentioned earlier that are needed in the twenty-first century.

Next Generation Science Standards (NGSS) These standards, which are intended to supersede previous standards sets, were developed by a consortium that included twenty-six states, the National Research Council (NRC), the National Science Teachers Association (NSTA), the American Association for the Advancement of Science (AAAS), and the nonprofit organization Achieve. The standards were introduced by the National Academies’ National Research Council in 2011 as A Framework for K–12 Science Education: Practices, Crosscutting Concepts, and Core Ideas (NRC, 2011), which was created as a guide for the states for developing their own standards. After feedback from education stakeholders, the final draft of the standards was published in 2013 (NGSS Lead States, 2013). The NGSS are organized from simplest to complex on a
three-dimensional teaching model following three concepts—science and engineering practices, discipline core ideas, and crosscutting concepts—and are organized by discipline and grade level (K to 12). Currently teachers in some parts of the country are trained on how to use the standards, and training is underway elsewhere. Assessments under NGSS are underway. The historical aspects of education and science education and their reforms and standards are an endless tale.

Summary

Chapter two has shown evidence of how American high school students perform compared to their international peers. As expected, studies show that American high school students are not performing competitively. Minority students—African Americans and Hispanics—score lower in comparison to White and Asian peers. I have explained the theoretical frameworks, CRT and LatCrit that guided me in this study, and explained that I chose these frameworks because the students I teach are African Americans and Hispanics. I went into detail about the ideologies of eugenics because I have assumptions that minority students are not completely ignorant about the past; they might not know the details, but the information they get about how science was used in the past might affect their interest in science today. I detailed studies that have been done on factors that help students do well in school, and some that looked at interest in science. I also went into detail about the history of science education in the United States, and how important science has been in shaping the American society over time and continues to do so today. The next chapter will explain how the study was conducted, Chapter three—methodology.
CHAPTER THREE

METHODOLOGY

This chapter will address all subtopics that pertain to methodology. These are: the research problem and purpose, research questions, my role as a researcher, research type, research setting/context, instrument, research sample, data collection and analysis, followed by a summary.

Research Problem and Purpose

Over the past 12 years I have observed my students at two inner city high schools showing very little to no interest in science. Their performances have been mediocre, and the students have not shown much concern about it. I did this study to find out from other science teachers if they have had similar experiences, and if so, how they dealt with it. I want to see my students take science seriously for the sake of better futures, and I want to see how I can improve my teaching in order to help my students.

Research Questions

My research questions are as follows:

1. What factors have robbed students of their interest in science as they moved from grade school, to middle school, to now high school?

2. Have students read or heard from family, teachers, or peers anything about science that made them lose interested in science?

3. In what ways do students see the importance of science to them as individuals and to society in general?
Research Design

My Role as a Researcher

As a woman of color having immigrated to the United States 30 years ago, I have had plenty of personal experience with the issues of racial inequality in the American society. I have to negotiate my position around other adults, coworkers, and administrators, so in a way I understand what students of color, particularly African Americans and Hispanics, feel when they are in schools or in other public places. My students choose to treat me as the “other” at times, but I understand why they would do that; sometimes they want to challenge me, or maybe they want to feel a little better about themselves. Since I am an adult and their teacher, there is always a limit to what they can say when they feel the need to treat me as the other. By my understanding of where they are coming from, they hurt, and they want to inflict pain on someone else. What better target than their own teacher with an accent? I did this research in order to help my students. It is not about me—I have a very good relationship with my students—it is all about them.

Research Approach, Setting, and Context

My research was qualitative. I wrote a series of questions that I distributed to participants some electronically and some hard copies with a consent forms (Appendix B) attached. The participating teachers answered in writing, and then I read their answers to see which areas needed clarification or further questions. I then scheduled an interview with each participant in a casual environment of the person’s choice that was comfortable for the open-ended questions used in QUAL data collection, making audio recordings.
Efron and Ravid (2013); Tashakkori and Teddlie (2010), and Creswell (2008) recommend the use of neutral, non-directional language in QUAL interview questions.

**Instrument**

I formulated my own questions for surveying the participants (see Appendix C), and asked follow-up questions during the interviews based on the responses I got from the surveys. This approach can provide insights into research objectives and assist in revising generalizations, according to Denzin and Lincoln (2008).

**Study Sample**

The participants were 13 science teachers from a large metropolitan area who were attending a summer professional development workshop at a local university. One was from a suburban school district, and all of the others from urban, inner city districts. Four were middle school teachers from four different schools, and the other nine taught high school, six of them from the same one. The total number of schools represented was eight. A fuller description of the participants will be in Chapter 4.

**Data Collection and Analysis**

I sent the survey questionnaires to the participants some electronically and some hard copies. After the surveys were returned, I interviewed each participant for 60 to 90 minutes. Efron and Ravid (2013); Tashakkori and Teddlie (2010, and Creswell (2008) recommend the use of neutral, non-directional language in QUAL interview questions. They further add that the questions should identify only one phenomenon, should begin with words like “what” and “how,” and should then be followed by practical sub-questions that are clear to the individuals under investigation. Denzin and Lincoln (2003)
emphasize the use of open-ended questions as well, on a single phenomenon, to allow room for flexibility for the researcher in order to explore the topic in depth.

I used iterative coding around themes for the data. I organized the data by codes, themes, and categories to identify connections, relationships, and patterns to pull the ideas together to answer my research questions, using Saldana (2013) as a resource. The 60 to 90 minutes interview that I did with the participants was for purposes of triangulating the survey data for clarity and expansion of unclear concepts written down. Triangulating is “a process of using multiple perceptions to clarify meaning, verifying the repeatability of an observation or interpretation” (Denzin & Lincoln, 2003, p. 148).

Ethical Considerations

Because I wanted to ensure the safety and confidentiality of the participants, I took the university’s IRRB training and followed all of the standard procedures for records integrity as outlined in Efron and Ravid (2013). On the consent form the participants signed (see Appendix B). I assured them that I would use pseudonyms, not their real names, in my records and reports to keep them anonymous, and that the digital records of their responses to the survey would be securely maintained and the paper records kept in locked cabinets.

Summary

In this chapter I have demonstrated why I needed to conduct this study, which is to find out from other teachers if they have had experiences similar to mine in their teaching of minority students who had little interest in science. I am concerned about the students I teach and their future, and I want to improve their learning and my teaching as well. I have also enumerated the research questions that I wished to have answered by
this study and described my role as a researcher. I further explained the type of research that I did, which is qualitative research, using surveys and one-on-one face-to face interviews with each of my 11 participants and analyzing the data using coding methods. Two participants were not able to do the one-on-one face-to face interviews because they were not available to do it at the time. However, they provided detailed responses to the survey questions.

The next chapter, Chapter 4, will present the data and analyze it.
CHAPTER FOUR
DATA COLLECTION AND ANALYSES

Introduction

This chapter will cover when, where, how, and from whom data were collected. From that point the collected data will be presented for each participant, following their answers to the survey questionnaire and the interview. The presentation will be in a narrative style, the data will be coded (Saldaña, 2003) to make it easier for analysis, and the codes will be developed into themes. Thereafter the themes will be put into a Venn diagram to compare middle schools against high schools based on the themes. The analyses of data will look back to the purpose and rationale for the study to see if they were fulfilled, to the study questions to see if they were answered, and to the conceptual framework to see how it laid the foundation for the study. All participants’ names as they appear in the data reports, as well as elsewhere in this text, are pseudonyms. After the analyses of the data, the chapter will conclude and foreshadow chapter five, the final chapter.

How Data Were Collected

Collection was done in two stages. First, every participant received an electronic survey questionnaire by email, and some manually. The surveys were returned to me, either electronically or as hard copies. I then scheduled a face-to-face interviews with participants, which took about 90 minutes for each. I used the same questions that were in the survey, concentrating on questions for which I needed more information depending on how the participants had answered them in the surveys. Further, if a participant mentioned something that was very important to the study, and if I needed an elaboration
on it, that was done during the face-to-face interview. The interviews were digitally recorded. Only two participants were unable to do the interviews, but these two had answered the survey questions in detail.

**July 13, 2016.** My advisor emailed me an approval letter from the university’s IRRB (see Appendix A). I called all my participants, who were all retired science teachers who attended church together, to let them know that they could sign the consent forms and work on the surveys. By the 15th I had spoken with all the participants, and they were all going to participate—nobody had changed their minds. I asked them to send the surveys back to me the moment they finished working on them. They all agreed that it would take two to three days to complete. I then agreed with them that I would call them to set up the interviews date and time after I received the surveys. Saturday, July 16th, I met with two participants who had requested an interview prior to participating. The two participants had demanded a different plan that involved my participation in their church sermons every Sunday until I finished the interviews. This was not possible for me because of time constraints, so I could not include these teachers.

**July 18, 2016.** I began participating in a weeklong professional development workshop at a local university that was being taught by two instructors from the university. Teachers from different districts in and out of my state would be attending. The daily schedule was 8:30 a.m. to 4:00 p.m., with one hour for lunch from noon to 1:00 o’clock. During lunch I asked the instructors if I could use a few minutes at the end of the workshop day to announce something personal to the rest of the teachers. They agreed. So, when that time came I stood up and explained that I was doing a study about little interest in science among students, and that I needed participants. I explained to them
about my time constraints, and asked if they could help me by taking part in my study. Basically all of them agree to do it. One of the instructors made a copy of the attendance sheet that had everyone’s name and contact information, and everyone agreed to receive the surveys that evening by email. When I got home I sent out the surveys and consent forms to all the teachers who provided the emails. I had asked the teachers to email the surveys back to me once they were done, or they could print them out and bring them to the workshop. I made copies to take to the other teacher, who did not provide email addresses, the next day.

**July 19, 2016.** When I arrived at the workshop that morning I was handed several survey printouts. A few others planned to work on them during lunch, together with those that I gave the surveys that morning. There were 20 teachers in attendance altogether (including me). Those who taught in rural or suburban schools were not suitable for inclusion in the study. I ended up with 12 teachers from the workshop who taught middle and high school with Hispanic and African American students and who formed a convenient study sample. To that group I added one more, a teacher who was not part of the summer workshop and who taught in a suburban school. I made the exception because he was knowledgeable about inner city students and was an all-around science teacher with vast knowledge—I considered him a walking science encyclopedia.

**Description of Surveys and Interviews**

The surveys had a number of questions under the following categories:

- **Part I.** Teacher’s demographic information
- **Part II.** Teacher’s personal attitude to science
- **Part III.** School information
Part IV. Teaching and learning experiences in science

Part V. Interest/attitudes/motivation

Part I and Part II were about the teachers: who they were, and how they got interested in science, and their educational levels. The other categories (Part III to Part V) were about the teachers and their teaching, their students’ interest or lack of it in learning, and teacher motivation of students. Data from surveys were triangulated with interview data using the same categories as in the surveys (Denzin & Lincoln, 2008; Efron & Ravid, 2013) in order to enhance the trustworthiness and validation of the findings. The survey and interview data are not presented separately because the interviews built on and validated the surveys’ results and thus increase the clarity of the body of data and provide elaborative information. The survey questionnaire can be found in Appendix C, and all participants’ interview transcripts are summarized in themes and will be analyzed in chapter five. These survey and interview categories were further explained as follows:

**Part I: Teacher’s demographic information.** In this category the participants were asked to provide personal demographic information: Their age, their race, their experience as teachers, and their experience as science teachers, and the highest degree they held.

**Part II: Teacher’s personal attitude to science.** In this category teachers were asked whether they went to college to become science teachers or switched to science after teaching other subjects, and they were asked to explain why. They had to explain how they got interested in science and why science was important to them and to their students. They were asked to explain whether or not the administrators of their schools
supported science, and to back up their assessment of their administrators’ support of science or lack of it with examples of what the administrators did or did not.

**Part III: school information.** Teachers were asked to identify the type of school where they taught, whether they were middle or high schools. They had to give general information about where the school was located, the size of the school (based on the number of students), the SES of parents (based on the percentage of free lunches), and percentages of students by ethnicities. The teachers mentioned the grades they taught, and whether the parents were supportive of science education or school in general. They were asked to provide information on tracking, whether the school and they themselves sponsored science clubs, field trips, and science fairs. They were also asked to provide the graduation rate in percentages for their schools.

**Part IV: Teacher’s teaching and learning experiences in science.** Teachers were asked whether or not they taught life sciences, and if they did which units/topics had they taught. Among the units that they had taught which ones did their students liked and which ones they did not like. The teachers were asked to explain why the students had such preferences in the units they liked and disliked. Then, teachers were asked if they taught physical science, and if they did what subjects and units they taught. From what they taught which subjects or units did their students liked and which ones they disliked, and why. They were to explain how important STEM/STEAM were to them and to their students, and why. In general this category was asking teachers to explain what they taught, their teaching methods and their students’ likes and dislikes of them.

**Part V: Interest/motivation/attitudes to science.** In this last category teachers were asked to explain and give anecdotes on whether they thought their students were
interested in science or not and whether they had noticed any differences in science interest by gender. Also, if they taught multiple grades and tracks, did they think their students’ interest in science changed with age—increased or decreased? They were also asked to describe how they discussed future plans (college) for science with their students; and whether or not their students mentioned plans to pursue science careers. The teachers were asked to discuss how they felt about their curricula. Did they have any control over the curricula? Could they make changes to the curricula, or not? The survey asked them if they used students’ cultural/ethnic knowledge in their teaching, and if so, to give some examples. A delineation of their techniques and strategies for motivating students were solicited, along with their opinions on how successful these were and their means for reaching those judgements. The teachers were asked to explain any misconceptions related to science that might have occurred in the course of their teaching, and how they dispelled them. They were queried as to how they assured equity in their teaching; for example, how they resolved any biases between teachers and students or among students. Lastly, the teachers were asked if they had ever encountered teaching situations involving old scientific theories associated with myths and/or ethnic stereotyping/prejudice/stigma and how they dispelled or resolved them with their students.

**Raw Data from Participants’ Surveys and Interviews**

The following were participants’ data, starting with high school teachers then middle school teachers. As mentioned earlier, all the names used are pseudonyms—participants’ and those whose names participants referred to in their responses. This group of teachers taught at the same school: Mr. Nash, Ms. Graeme, Ms. Dowdy, Ms.
Williams, Mr. Zubek and Mr. Johnson. To avoid repetition, only Mr. Nash’s section will carry the school information. Each interview took place at a time and location convenient for the responding participant.

Mr. Nortek Nash: 7/19/2016, 5:00 p.m.–6:30 p.m.

I interviewed Mr. Nash at his home an hour after the workshop that he and I were attending. I thanked him for allowing me to interview him after such a long day.

Part I: Teacher’s demographic information. Mr. Nash was a 40-year-old Caucasian man, over six feet tall and athletic looking. He held a master’s degree and had 14 years of experience in teaching science at his current school. He said that teaching was his first real full time stable job after he graduated from college. I thanked him for his detailed answers to the survey questionnaire, saying that having it in hand might cut down the amount of time we would spend in the interview. I let him know that I wanted to get rich and detailed data, so I intended that we would have a talk, not just a question/answer session. He agreed, and said that it was nice, because sometimes it was hard to remember information when you’re aware that you are being recorded. I told him not to worry, to relax and feel like he was in a regular conversation with me.

Part II: Teacher’s personal attitudes to science. Mr. Nash got his master’s degree to be a science teacher. He said, If I did not choose to be a teacher, I would have had to be a researcher, a profession I did not like; besides, I like working with teenagers.

Mr. Nash said that he had always been interested in science, and his interest was further amplified in high school when he met a teacher who really opened my eyes to what science had to offer. Prior to high school his father would take him to a NASA facility like a warehouse, with a lot of old space shuttles, some small models, and toys to look at,
but for him that was too boring because it was not a place where you could ask a question. *There were no people to talk to.* His father took him there because he had shown interest in astronomy. His father also took him to a natural history museum, but he was not interested in anything in it—he took it like a place to go just to get out of the house. In high school he took biology as a freshman, a class with some seniors, and the following is the description of his experience in that class.

The teacher spoke in a super monotone, and the seniors put their heads down and fell asleep; only freshmen listened to him. I do not remember what I learned about biology, even though it looks like I learned something, because I know a little bit about biology, and I never took biology again until when I was in college when I took one course in paleontology. One thing I remember about my high school biology class was how to put the microscope away: it involved wrapping the cord around the neck and holding it with both hands, one at the bottom of the base and the other on the arm.

Mr. Nash said that in his sophomore year he took chemistry, and that was his eye-opening experience for science. The teacher was nothing like the freshman biology teacher. The teacher was unique. *I have never met anybody like Mr. McIntyre—he built things.* Mr. Nash said that Mr. McIntyre took his old Volkswagen bug and turned it into a pickup truck. He explained,

The pickup was very fascinating to every student. I don’t remember much about how the chemistry lessons went, but I learned enough chemistry that year. The things that he was building did not have a direct application to chemistry. In my sophomore year I took physics with Mr. McIntyre again. This time all the stuff he
was building and we had helped him with were put to work in the classroom. He organized the classroom in such a way that it was like an independent learning setup, but not totally. We worked in small groups, and everyone had to go to the board and write the answer to questions he would give us. If a person did not know what to write, he/she still went to the board and the rest of the class would help. That was the best class ever. I took a second chemistry class in my junior year, with Mr. McIntyre again, and I had very good grades. But in this second chemistry class we did more work—there was no more building of stuff.

Mr. Nash finished high school with very good command of science, but, he said, he never intended to become a physics teacher. That came much later. In college he took two courses in chemistry. *In the first course I did not attend class, I only went in to take quizzes, tests, and exams, and I aced all of them because there was nothing new. It was all [material] I’d learned from Mr. McIntyre.* The second course however, required him to attend classes, because everything was new. He did not like the lectures or the style of teaching, and he changed his major to engineering. In engineering he was bored stiff.

There was nothing that mirrored the experience he had had in high school with Mr. McIntyre. He changed again to take up economics, and *I learned a lot about how to make money and to be rich.* So after he graduated from college, by then in his early 20s, he started to think about his future. He recalled that his interest in astronomy was still in his head. *With my degree I had three options: I could do research, be a banker, or be a real estate mogul, but none of those interested me.* He ended up finding out that the planetarium in his city needed volunteers, and he applied. *I was given a very good assignment, to run shows, and I was working with real smart people.* In the midst of
volunteering he visited a store called American Science and Surplus, and in there after wandering around he bought an astronomy magazine. He left the store and got into a bus to make his way home. Here is his account of his acquaintance with the magazine.

I started reading the magazine. I did not take my eyes off that magazine until the time the bus reached my stop. By then I had read the magazine cover to cover. What a surprise! The magazine had just given me the whole interest back. It was like I [had] discovered something new that never existed before. I was now sure my volunteer work at the planetarium was a good choice, and my life was going the right direction from this moment forward. I worked at the planetarium for two years, but part of it I was [as] a paid employee. I just rediscovered my passion, and off I went to graduate school to take physics and to become a physics teacher. Two years later, here I was teaching physics [and] up until now, 14 years.

Astronomy is still my favorite. I had taught astronomy in the past and had an astronomy club for few years. But now I don’t have time to run the astronomy club. But astronomy remains my passion forever.

As for the importance of science to him and to his students Mr. Nash said that science was important for the fact that students would be confronted with important decisions in life that would require at least a basic knowledge of science in order to make good decisions. Also, technology is rapidly changing society and science helps to understand what is safe or dangerous about technology. Despite the importance of science as he saw it, he did not see any special interest in science on the part of administrators at the school. But he added that they were generally supportive. He elaborated, saying that he felt that maybe they had to give equal support to every
department lest they favor one department over the others and create a problem.

However, he explained, *if an administrator was originally a science teacher or was from a science background, maybe he/she might pay more attention to science.* He mentioned a program on television, *Hotel Impossible* that featured an individual who went around advising hotel owners on how to keep their hotels clean. He said, *I watched one episode with my family, and it was all common sense involved, like the proper way to clean a toilet.* He said that the importance of science is that it is all common sense in daily life, and people need to know its importance. It is not necessarily for everyone to become a scientist, even though that would be great, but of course, unrealistic.

**Part III: Teacher’s school information.** Mr. Nash taught at a large high school in a large metropolis in the US Midwest. The school could enroll up to 4,000 students, but currently it was around 3,000, with a graduation rate of about 85%. The student population was broken down by ethnicity as follows: 81% Hispanic (majority Mexicans), 12% African Americans, 3% Asians, 3% White, and 1% others. This breakdown was also represented in all the classes he taught. He did not have the information regarding parents’ socioeconomic status, but judging from the reduced or free lunch rate of over 90%, it looked like the parents were predominantly of low income. He reported not having had enough contact with parents; at report card pickup times, he met just a few. For this reason he did not have enough evidence to judge whether or not the parents supported science. His school used tracking, starting with regular tracks, to honors, International Baccalaureate (IB), to AP. He also taught all levels from time to time except AP. The school is a magnet performing arts school, but it also has vocational arts departments in business and in drafting. Mr. Nash sponsored a club he called a
conservation corps, in which students were involved in recycling paper, but the club generated other activities that expanded to school-wide initiatives. As far as field trips and science fairs were concerned, he did not participate, but his students could choose to participate in science fairs on their own and could get help from him. I don’t think there were more than 1% of students who participated in science fairs, he added.

Mr. Nash’s students were interested in physics. Physics was an elective course, so except for the IB students, who were required to take physics as part of their curriculum package, these were students who had taken all the other science courses required for graduation and had chosen to take physics. They appreciated the challenge physics offered, and he allowed them to do a lot of self-directed activities that increased their interest. However, in Earth/space science and environmental science where he taught regular track students, he did not think the curricula for these two subjects were well developed, and students’ attendance was a problem. He also felt that students who took these two courses did it because they felt that they were easy compared to, say, chemistry and physics. They just wanted to satisfy the graduation requirements and were not necessarily interested in the subjects.

Part IV: Teacher’s teaching and learning experience in science. Mr. Nash taught physical science exclusively, never life sciences. Referring to his comments about the less-developed curricula for them, he said, Curricula apart, the students in regular Earth/space and environmental science look like they have had bad experiences with other teachers before they met me. He said that by the time they met him they had given up on science, and they took those courses only to be able to graduate. The last question in this section was about the importance of STEM education to him and to his students.
He said that STEM was very important, but it was not a new thing for science, and especially not to a physics teacher. He said that it is a catchy acronym, but as far as he was concerned, he had done STEM with his students ever since he became a teacher. He elaborated, The S-science, T-technology and M-math—*I made sure that students got those in almost every lesson*. He explained that the E-engineering comes in as intuition, by experience and practice, and that was exactly what he had done with his physics students. He added further, *I have had a few students who are engineers and even made more money than me, and I am very proud of them. Now you see how old I am.*

Mr. Nash felt that he would focus a little bit more on engineering than he had done before with his students. He reminded me about his experience in college, where he had found engineering very boring. He was sure that it was simply a matter of the way it was taught, and he did not want his students to feel the way he had felt. He explained that he bought some probes and other equipment that students could use to work with him to put together some working devices for teaching. He said that he had a physics budget from IB and the science activity funds from the department. Altogether he had equipment worth $2,000. However, some of the probes were very sensitive, and he would need to budget his time to learn how to use them before he could teach his students. *May be I will buy some old electronics, like old speakers, things like that, for students to have fun with by taking them apart and putting them back together before I allow them to use the expensive equipment."

Talking about the importance of STEM/STEAM for students and society in general was very interesting to Mr. Nash. *Society has to be vigilant over every aspect of life. The food people eat, is it safe? All the time? The water people drink, is it clean and
safe? All the time? He gave the example of Flint, Michigan’s, water problems, and other examples involving products that are used in households about which people need to be informed in order to keep children safe. He spoke about a geochemist called Clair Patterson who developed what was called a ‘clean room’ concept in his attempt to make sure he knew the content of lead in stuff. This scientist dedicated his life to getting rid of lead in everything people use once he was able to demonstrate to society that lead is poisonous to children. This was not an easy undertaking when powerful industry lobbied the politicians to keep their businesses going, and there he was a scientist who had no equivalent amounts of money, but knowledge. As they say, knowledge is power, and eventually the knowledge won, and lead was banned from use in gasoline, in paint, and in many other products that come in contact with children. He continued by telling me that there were an entire 12 episodes of the TV series COSMOS: A Spacetime Odyssey dedicated to Clair Patterson’s effort to expose the dangers of lead and the background for it, which could be a good teaching tool. I promised him that I would check it out, and he agreed that he would use it in his teaching, too, which he had never thought about until now.

Mr. Nash talked about another aspect of the general public’s struggle to be knowledgeable about science, that it can get very confusing when people listen to editorialized infomercials about products that scientists have somehow supported as being good for people to protect them from some diseases or conditions, only to hear about the very same products not very long afterwards now being declared bad, able to cause severe problems. These types of information in the media not only mislead people, but give scientists a bad rap, he concluded.
Part V: Interest/motivation/attitudes to science. Mr. Nash thought that deep inside the students’ minds there was interest in science, but they have had a lot of bad experiences in schools and out of schools, and they gave up too early. I asked him why he thought that might be the case. He said that he was speaking about his regular classes that he taught with special education teachers. His analysis of the students’ attitudes and interest in general made him think that probably the students had had a bad experience with their previous teachers in lower grades and in freshmen and sophomore years at high school before they met him. In his teaching he said that he had not seen much difference between boys and girls in matters pertaining to interest, motivation, and attitudes to science.

He also said that since he taught mostly 11th and 12th grades, it was hard to evaluate whether there was any increase or decrease in interest by age. He noticed that students who were interested got themselves ready for college choices and applications. After that they were preparing themselves for graduation, so it was hard to tell unless he had taught all four grade levels. He said that he always talked to his students about future careers in science, especially with those who had some science careers in mind. He encouraged them to pursue their dreams in science or anything that they wanted. Mr. Nash estimated that about 15% to 20% of his students aspired to be engineers, but only a few went directly to college after high school. He hoped that the rest might follow their dreams later even if they did not start by going to college right away. As for curricula, he said that the IB curriculum came in done—there were no changes that needed to be made to it—and he praised it as the best curriculum he had ever seen.
He said, however, that other than the IB curriculum, he had total control of the curricula for the subjects he taught. I am the only main physics teacher. A few others, who teach physics [only] once in a while, have accepted the curriculum I created. He continued to elaborate, saying that he borrowed from the IB curriculum to create the physics curriculum for non-IB students. On the question about tapping into students’ ethnic knowledge or talking about ethnic scientists as a way to motivate students, he told me that this was probably his major shortcoming in his teaching, but now that I had brought it up, he said, I will start to include ethnic knowledge and names of minority scientists and women in my teaching. When it came to motivating and engaging students, Mr. Nash had a lot to say and was very animated about it. He said that his IB students were engaged and paid a lot of attention in class, that they saw the value of science. I have these kids for two years. I share things about myself, and I push them to do things. The IB students stay after school to get extra help from him. He said that he had developed a personal relationship with all of them, and after two years with him they had made solid progress and had developed a strong interest in science. With that he added, I talk to them about my relationships with my parents, my teachers, things about life. He went on to say that he told his students to be prepared, because if they loved their parents, and their parents certainly loved them, one day you will want to take care of your parents, who might not even know you anymore because they are sick. Imagine if you are not able to do that because you wasted your time and their money playing instead of learning something to help you get a stable life. He said that once he gets into these talks with students, he knows they are listening. Not even one person asks to go to the bathroom or puts his/her head down.
He said that one semester he taught night school. The first thing he did was to print report cards from two other schools with similar student populations like his. He also printed his school’s report card. He brought them to the night school class. Once the students sat down and he did attendance, he asked them one by one to explain why they failed the class they were now retaking with him. Each student gave his/her reason why they failed the class. So he showed the class the report card for the school and asked them to pass it along for everyone to take a look. After they were done, he passed along the other two report cards from the other schools. After the students finished looking at the report cards, he asked them what they observed, and they made their comments. He then asked them why the other two schools performed better than their school, and the students started to give their answers. *Those kids are smart, they have better teachers, they are rich,* and many more excuses. He asked them, *if an alien were to visit Earth to study high school students, would the alien land at [our] school’s parking lot or at the parking lots of the other two schools?* Nobody said a word this time. So he told them that he did not think an alien coming to get knowledge from high school students on Earth would care to land at a school with failing students; the alien would want to learn from smart students. He continued to talk to students about their failure. He told them that the students from the other two schools were of the same ethnic groups as they were, so it was not about race, or ethnicity, but simply that those who want to succeed do succeed, and those who do not aim to succeed find excuses to justify their failures. He said that he used race to get students “fired up.” He then continued to tell them that their below average performances were not just about them, that they were affecting the whole
school, the parents, the community, the city, state, and the whole country. He said that his talk took an hour, and then the students got ready to do some work.

Night school for one course was held two evenings per week, and in their second session Mr. Nash gave another motivational talk, about money. He asked his students to guess how much money from taxpayers was used for education in the district. Mr. Nash brought in statistics about money and the school district budget. He also brought in his tax returns and a calculator. He showed the students his salary, telling them that he was not at the low end or upper end, but somewhere in the middle. He said to them, *I am by no means a rich person, but I live comfortably with my wife and our two children.* He showed the students how to calculate how much money was used to pay all the teachers at the school by taking the average salary for a teacher and multiplying by the number of teachers in the school. The students were surprised.

He then gave them the amounts of money used to pay for the other staff and for keeping the building in good condition. He then showed them figures for how much money was needed to educate one student per school year and had them multiply by the number of students in the school. He said that the students were stunned. He went on to tell them that he had been paying $4,500 in property tax to support schools, and that he had paid that even before he had children of his own, and that everyone paid regardless of whether they have children or not. So then, he told the students, the money had been paid for them to take the class, but they had decided to play around and had failed it. Now, instead of someone coming to them with a bill for them to pay back the taxpayers, they had actually been given more money to enable them to repeat the class. He asked them,
what do you think of that? He said that the students kept quiet, looking at him kind of ashamed.

He asked the students, *do you think every young person around the world can go to school?* Some students said “No” and some said “Yes.” He asked them more questions. *Do you know what happens to girls who want to go to school in Afghanistan?* Nobody knew. He got no answer, but he could tell that the students were thinking. He told them, *girls in that country can get killed for going to school.* They have to use a different route every day to avoid the men who want to kill them or throw acid at their faces, just for wanting to get an education. *Some men in Afghanistan do not believe that women should be educated.* He went on, *I understand that some of you come from neighborhoods with gangs and other problems, but has anyone ever tried to kill you—kill you!—for wanting to go to school?* After this talk, students started to do their night school work, and from time to time he shouted out the amount they calculated for educating one student, as a way to remind them that people paid for their education, and they better keep that in mind. He told me, *I use these two basic talks to all my students, but I modify certain aspects of it depending on who is in front of me.* He continued, *go to my classrooms, any classroom, and ask the students, ‘How much money does Mr. Nash make per year?’ They will tell you the right amount. Ask them, ‘How much money does Mr. Nash pay in taxes to support schools every year?’ and they will tell you the right amount.*

Mr. Nash said that he did not come across misconceptions in his physical science subjects. If there were any, they would be misunderstandings of how something works, and those were better addressed in labs or in class demonstrations. As far as negative
attitudes toward science were concerned, he said that those were common, showing particularly in what students verbalized. When he confronted students who were not participating, for example, they might say something like, I don’t care, or I hate physics, it’s too much work, I am tired. He said that he does not take such attitudes seriously. He knows that the students might be tired, mostly because they did not get enough sleep the night before, watching TV, talking on the phone, and other teenage activities, but he always tries to find a way to engage them, and there are times when I get angry and might say, ‘Why are you even here?’ He said, I have the best relationships with my students, and some who are not even mine, of any teacher in my department. He told me that I have his permission to check on this if I wanted.

Mr. Nash wanted me to know that he did not plan for these motivational talks, they happened spontaneously after the frustrations of trying to teach some kids who seemed to care about nothing. I even told them that at one time my dad worked as a janitor scrubbing floors and toilets. He added that he knew that some of his students might laugh it off when he gave those talks, but he did not recall any student showing any type of disrespect towards him, and they could do that if they wanted. He said that the majority of his students paid him respect because of the talks. One of his students who is now a teacher came to see him and told him that she had become a biology teacher. She said she was using his teaching styles, and among those were talks of her own to her students. He said that he was happy to hear that the talks had actually influenced at least one person, and that was enough for him.

Mr. Nash’s latest talk on motivation had been about Michael Jordan. He told me that he had used Michael Jordan’s struggles and then success with the Bulls basketball
team to help his students take control of their learning. He started the story with, *when Michael Jordan started to play with the Bulls he was very thin like a stick, but he was good at dunking.* The Pistons were a rival team, and they were very physical. They knew that the Bulls were a young team and Jordan was the only player they depended on to dunk, so they had a plan to make sure that they would be very rough and double team him so that he would not get a chance to dunk. *They were successful!* He said to his students. *What did Jordan do? Did he whine? Fret? Kick up a fuss? Get an attitude? No!*

*Do you know what he did?* He said that his students had a number of answers to this, but nobody got it exactly right, so he told them, *Jordan beefed up!* He gained 20 pounds and developed bulging muscles. *So who was taught a lesson this time? It was the Pistons….Jordan went on to win six championships.* He said that he use MJ’s story to help students understand that it is up to them if they want to be successful.

Our last discussion in the interview was on equity, because Mr. Nash had indicated in the survey that he did not understand the question. He said that he tried the best he could in his regular classes where he co-taught with a special education teacher to make sure that all students benefitted from his teaching. However, there could not be a way to differentiate or tailor to each type of learning. He use his MJ talk in this class as well, and then give students some options. He had set a table in the back of the classroom, and over there he had a computer and a list of short videos students could access on YouTube to learn how things work. He allowed students to work in small groups while he and his co-teacher hover around to help. He also had another corner in the classroom where he kept a desk for whomever might choose to work alone and ask for one-on-one time with the teachers. He helped students understand that they should use
their own strong learning style and try to enhance it with other learning styles they pick up from other students. He taught them to advocate for themselves, because it was not going to be possible for a teacher to keep every student’s learning style in mind, and it was better for students to know and use other learning styles in addition to their own basic one(s).

We finished the interview with an agreement that I could call or email him if I or he should have more questions. Mr. Nash had a lot to say about who he was, his teaching, and his students. There are not many teachers, me included, who could or would share so much about themselves and their family with students. His stories were very important for students who might think that science was not for them, showing that even simple things like cleaning a toilet properly was science because it helped the hotel keepers to avoid spreading germs. The story about lead was particularly fascinating, because students should understand why lead is bad for them, and should know about the scientist who worked so hard to expose the dangers of lead in household products. Mr. Nash was as excited about science as he was in high school with his favorite teacher, it seemed.

Samantha Graeme. 7/23/2016, 10:00 a.m.–12:00 noon.

Part 1. Teacher’s demographic information. Ms. Graeme is a 34-year-old Caucasian woman with eight years’ teaching experience. She worked in the environmental field before she switched into teaching. She has a master’s degree in environmental science with a chemistry endorsement.

Part II. Teacher’s personal attitudes to science. I met Ms. Graeme at a restaurant in her neighborhood where we had agreed that we would have a brunch as we
did the interview. But the noise level was too high, so we didn’t start the interview until after the meal when we went to a nearby park.

Ms. Graeme stands about five and a half feet tall and has reddish hair. She wore a stern professional demeanor even though we were at a restaurant. I did not see a smile on her face. I asked her when and how she got interested in science. She said, I don’t know—I’ve been a science geek for as long as I can remember. She said that she could not remember how it happened, but she started liking science on her own; she did not think there was any influence from anyone. I asked her to explain why science was important to her and to her students. She said, science helps students to practice critical thinking processes and to gain an understanding of the world around them, and that is the same for me. She said, however, that she did not feel that there was any special emphasis on science from her school administrators. She added that the school is a magnet for performing arts, and the arts might have been the area the administrators were supporting.

Part III. Teacher’s school information. Ms. Graeme told me that she did not know much about her school’s parents because they did not show up during report card pickup days. She continued to say that she has tried very hard to call them to invite them to school, but she gets to see only a very few. She teaches regular students, honors, and AP, as well as IB. She also sponsors a science club called Green Action Alliance. She has taken students on field trips and ran an unsuccessful compost club. She does not like to sponsor science fairs, but has sometimes been forced to do so. She explained how science fairs are organized in her school’s science department.

Two teachers are usually coerced into sponsoring the science fair and advising students after school on their projects. It is difficult to persuade teachers or
students to participate, because there is little perceived benefit for either party—it is a lot of hard work for a meager pay for the teachers, and a huge amount of work for already overloaded students. It is voluntary for most students, but occasionally a teacher will require all students in their classes to participate.

She addressed field trips that she takes with her students as part of the Green Action Alliance. She took students to a forest preserve on a monthly basis to do volunteer work that involved learning about the ecosystem and habitat restoration. She explained more about the field trips as follows:

Any student who is interested can join the club, and I have about 100 students. The forest preserve provides the bus for the trips. I recruit my family members, older siblings of the students, friends, and former students to chaperone. Onsite, the students cut down invasive species like garlic mustard and throw them onto a bonfire, and then the park employees put herbicides on the remaining roots and stumps. The AP environmental science classes also go on field trips twice a year as a requirement for field research.

I asked Ms. Graeme about the compost club she mentioned as having been unsuccessful. She said that her students lost interest. They joined the club to get service learning hours, and once they had in enough hours, they stopped coming. When I asked her about her plans for this club, she said that she would not stop sponsoring the group because there is another teacher who sponsors a garden club that depends on the compost for enrichment. I wondered if she could get another teacher to work with her, but her response was that she had tried that option before with no success. However, she
elaborated on her plan for the next school year, because she is not ready to let the club go. This was what she said.

Next year I will make the compost club into a project which will involve educating the students about composting. This way they won’t feel like they are removing some leftovers from the cafeteria without some knowledge behind it. I also need to educate custodians and cafeteria workers so that they don’t remove the buckets from the cafeteria because of not knowing why the buckets are there or why my students are collecting the leftovers.

I asked Ms. Graeme to explain the difference between the AP field trips and the Alliance field trips. She said:

The AP field trip is a one-time trip to the forest preserve unless students are also in the club. Then they will get a chance to go more than once. This field trip involves a two-day classroom period of planning and designing a project. Then they go to the preserve to collect data. Normally [the research focus] is the effect of an abiotic factor on a biotic factor. Students will get time to organize and analyze data. They will then publish on poster boards. This is a two-week mandatory project that every AP student must do.

**Part IV. Teacher’s teaching and learning experience in science.** Ms. Graeme thought that her students might find ecology the most interesting unit because they are able to go out in the field and see it in action. When she teaches environmental science, she gets into evolution, but not too much. Unfortunately, her students show lack of enthusiasm and retention of material on evolution. In general she felt that her students like environmental science a little better than chemistry, because in a way they can see its
connection to reality and can relate to issues that might affect their own lives more than they can for chemistry.

Her response to the question on STEM/STEAM importance to her and to her students was as follows.

STEM is very important to me, because I understand the need for us to find solutions to our environmental problems. It is important to their futures because so many careers in the future will require STEM skills, but it doesn’t seem that they are thinking much about their futures.

Part V. Interest/motivation/attitudes to science. The question was whether the teacher thought the students were interested in science. Ms. Graeme said this:

Most do not seem to be interested—a rather small proportion of our students take the optional fourth year of science course. This may also be because they have the perception that physics and chemistry are too difficult for them. I also do not encounter many students who show any real initiative in science; they seem to go through all the motions of the work, but don’t care about really learning it.

She could not say for sure whether there were any gender differences in interest in her classes, but she said that she always had more girls in AP environmental science than boys. She did not notice an increase or decrease in interest by age. If she were to compare her regular students and AP students, she could say that AP students were a little bit more motivated than regulars. However, this year the AP students did not perform at an AP level. She thought that the only reason they signed up for the class was simply to improve their GPAs. They did the work but did not put in enough effort. After a while she recalled two girls, former students, who had done very well. One girl she described as a star in
Science was in college studying engineering, and the other one was hired by the forest preserve where Ms. Graeme took students on field trips.

On the question about students’ future plans in science, Ms. Graeme said that only a few students care to want to hear about future plans, like college or after college. The majority show such disinterest in science that I do not bother to ask. She had a former student who sought an internship with the National Laboratories and other science programs.

I asked Ms. Graeme about her science curricula. She said that the curricula were pretty strong, but her critique of the biology curriculum was that she had always felt that it was too advanced for an introductory course, spending too much time on complicated topics like genetics and photosynthesis and not enough time on more relatable topics like zoology and botany. She said further, I am not a biology teacher, and I use just a little portion of biology for my environmental science classes. But all students must take biology as a science requirement. I feel that for that reason biology might be turning young students off of science. About chemistry she said:

I am lucky enough to be able to teach an alternative curriculum based on an environmental-based textbook, which I chose over teaching a more conventional curriculum. This textbook will help students grasp the learning of chemistry using environmental factors related to chemistry. It explains better why you are learning it. The curriculum is written, so I will not have to reinvent the wheel. The administration had problems accepting it, until they realized its validity.

Ms. Graeme did not recall any negative attitudes about science from her students, but mostly just apathy. She said that she did not understand the question about equity
even when I explained. My explanation of equity had two part to it. First, I asked her if
she had ever experienced a situation where students felt that she was not fair, given that
she is White and the students are from minority groups, and if such situations had existed,
how she had handled them. Secondly, I explained that the students could treat each other
unfairly given the fact that they were from different ethnic groups—among other
differences—and asked how she made sure there was fairness among students.

The last question was about theories prevalent in science to which the students
might have had negative reactions that could have contributed to their lack of interest in
science. Had students demonstrated any misconceptions about science? Had any stigmas
or stereotypes resulting from science theories that the students held been revealed in her
classrooms? Ms. Graeme did not think there were such instances, and said that
environmental science is not a discipline with many theories.

At this point it was approaching noon, and a lot of people were out and about in
the neighborhood and in the park where we were. Before long, young children around us
became interested in our conversation the moment they saw the tape recorder. At the
same time we were in the midst of ambulance and police car sirens. Fortunately we were
done before this became too troublesome. I asked Ms. Graeme if I could contact her in
case I had more questions. Most definitely, she responded. I thanked her and wished her
luck on the several short trips she planned to take that summer.

Overall, Ms. Graeme was very precise in answering her questions; she did not go
into detail unless she had to. She preferred not to answer the question about equity, and I
did not persist. She works hard to be able to sponsor two science clubs and take students
on field trips. She did, however, show a level of frustration when I asked her about
students’ interest toward science and whether she spoke with them about their future plans for science. I can relate to her frustrations. When students show no interest, it feels like they are working against you, the teacher, and it can be frustrating and exhausting.

Ms. Miriam Dowdy. 7/21/2016, 5:30 p.m.–6:45 p.m.

Part I: Teacher’s demographic information. Ms. Dowdy was a Caucasian woman of Polish descent in her 60s. She had been a science teacher for 26 years. She looked frail and worn out, and she had told me that she had not been in good health recently. I went to interview her at her home after we had parted from the whole-day workshop.

Part II. Teacher’s personal attitudes to science. Ms. Dowdy grew up in a farm, and started liking science through observing nature. She had majored in science when she went to college, and had been a teacher ever since. She knew that science is important because it is a way to understand the world, and that it is important for students to learn about science. She was not sure whether or not the administration of her school was supportive of science. She said, I don’t bother with them. I come in, teach, and go home.

Part III. Teacher’s school information. Ms. Dowdy had not observed a good relationship between the school and the parents. They hardly show up for report card pickup. It is very difficult to reach them, especially when students are not doing well, not attending, cutting class, or are having behavioral problems. Ms. Dowdy neither sponsored science clubs nor took students on field trips. She participated in a science fair if she was required, but not voluntarily. However, if a student of hers or another teacher’s needed her help for a science fair project, she always offered the help. A few years back when the head of her department demanded that every science teacher sponsor a science
fair and have at least two students participate, I was left with no choice but to sponsor science fairs. She did not think the participation was worth her or her students’ time, because she was forced to beg students in order to come up with two who would participate. Eventually they would agree to participate after feeling sorry for me, but she did most of the work on the projects by herself, because the kids did not want to be bothered. I could not blame the students; it was really a waste of time to force this on us [teachers] and students, she added.

Part IV. Teacher’s teaching and learning experience in science. Ms. Dowdy taught biology and Earth/space science for regular level sessions. This past school year she taught only biology to majority freshmen classes. She said that the only topic students liked a little bit was genetics, when they examined their dominant and recessive traits, like the ability to roll their tongues and things like that. Otherwise there was very little interest in any topic. She expressed the following regarding her students:

Most students come to school to socialize. Maybe socializing is good, but learning should happen too. When I try to talk to them about their future [they usually respond], “I don’t need college. It is too much work. I know how to get easy money, and I don’t need a college debt.”

When I asked Ms. Dowdy if she had noticed any topic from biology or Earth/space science (she sometimes taught environmental science as well) that students liked. Shaking her head, she responded:

It is hard to say. Everything depends on the student and their level of interest, which is zero much of the time. Most students only want extra credit at the end of the semester. Also, it is very hard to engage them in the analytical aspect of
science. They only want to know the results/effect. They are not interested in how a solution/theory is developed.

I asked Ms. Dowdy about her take on STEM/STEAM education and how she helped her students understand its importance. She gave a lengthy analysis.

Analytical and critical thinking skills gained in STEM translate into many careers. It is very important to me, but for my students’ future, I believe these skills can help them to go very far in their careers, if they will have them [careers] eventually. Many students are simply not interested in science. I really don’t know what they are interested in, because I hear the same comments from teachers of other subjects. STEM and STEAM are preparations for post-secondary education and employment. They are supposed to start at an early age—elementary level.

**Part V. Interest/motivation/attitudes to science.** The question was whether students were interested in science, in a general sense. *Some are, she said, however, a majority of students are more interested in a materialistic lifestyle. Most play with their iPhones instead of listening in class.* As for students’ interest based on gender, Ms. Dowdy has not observed any difference. As far as interest increasing or decreasing with age, she was doubtful, *I cannot really say, because I have only taught high school.* She recalled that when she taught the 11th and 12th grades, she has discerned *a little bit of a sense of maturity maybe in behavior, but not necessarily in academics. Actually, I think it got worse.* She recalled, *senior students were sleeping in class and then begged for a “D” so that they could graduate.* As for future plans that involved science, from time to time she would hear someone say, “I will be a veterinarian because I love dogs and cats.”
Some would say they would work in health fields. She continued by saying that it is possible that the students may one day grow up and do these things they talk about, but currently there has not been any evidence they would do what they say. The majority of her students have mentioned that they want to finish high school and get a job.

Ms. Dowdy used the curricula as given, because teachers of the same subject planned together, and this had been taking place for years. She did not see anything wrong with the curricula or syllabi. She told me that she connects some of her lessons to relevant ethnic knowledge when it is possible. She gave an example about Mexico. I once showed a video on the Cave of the Crystals in Mexico. Students found it interesting because they did not know it existed. Sometimes I discuss pollution in certain areas where the majority of my students live. To dispel negative attitudes, she encourages her students to reason through evidence as to why they might want to hold onto some notion that has no scientific backing. I don’t know if it ever works, but I try, she lamented. She added that she has tried very hard to tell students to treat each other with respect, just like she treats them.

To the last question, about old science theories that might creep into the classroom, Ms. Dowdy’s response was that when she teaches evolution, she asks students to try to remember a belief, maybe in the family, for which science has shown evidence to disprove it. She encouraged students to ask their parents about things that they believed about in the past that were later dispelled by scientific facts. She told her students that religious beliefs cannot be discussed in the classroom because they are not science. Science requires supporting evidence.
Ms. Dowdy had filled out her survey in detail, so we did not have to go through all the questions in the interview. I had carried her survey with me, and only areas that needed elaboration were discussed. She told me that she was going to be busy, and unless it was really necessary she preferred I did not email or call her over the summer. I thanked her for everything and promised not to bother her over the summer.

To summarize, Ms. Dowdy is a very polite lady. She had frustrations similar to those of Ms. Graeme that were evident as she spoke about her students’ lack of interest in science. She was very honest about what students tell her regarding their future plans, and she really did not hold back expressing her frustrations about her students’ attitudes to science. Her answers, both written in the survey and spoken during the interview, clearly showed her concern for her students’ desire for expensive consumer materials over their educational attainment. She was concerned about what she had told me, feeling she may have expressed herself too freely. I assured her that that should be her last thing to worry about, since I maintain confidentiality as was indicated on the consent form.

Brianna Williams. 7/23/2016, 3:30 p.m.–5:00 p.m.

**Part I. Teacher’s demographic information.** Ms. Williams was a 38-year-old Caucasian woman with eight years of teaching. She was about five feet four inches tall, with brown hair and olive skin. She had attended graduate school to become a science teacher, and had started as an environmental chemist before beginning to teach. I met her in the parking lot of a shopping mall. She had come there with her family, and her husband with their children went off shopping while she and I conducted the interview in her car that was parked under a shade. I thanked her for completing the survey.
thoroughly, which would reduce the time we would need for the interview. It was a very hot day, and we had to have the car running for its air conditioner to keep us cool.

**Part II. Teacher’s personal attitudes to science.** Ms. Williams’ interest in science started from childhood. She grew up on a farm where animals and crop cultivation were around her, so she had had a lot of exposure to nature. She came from a family with interest in science. *My father was an electrical engineer, and my grandmother was a science teacher at a women’s college. She collected butterflies and had different types of these, and those were available to me as a child.* She has two brothers, *one a park ranger and the other a physician.* She continued, *Science is very important for students to understand the natural world around them, to make informed decisions regarding controversial issues such as global warming, genetically modified organisms (GMOs), fracking, alternative energy sources, conservation, health and medical issues.* As far as school administration support for science was concerned, she said that her school was a performing arts and technical magnet high school. The administrators were new, had not been there long enough for her to really assess their support, but she knew that *the principal has supported science fairs.*

**Part III. Teacher’s school information.** Ms. Williams taught regular biology, Middle Years Program of IB (MYP) biology, and honors forensics. She sponsored a garden club and obtained nutrients from the school’s composting club for them to use. She did not think, however, that she would have time to continue sponsoring this club. She explained that participation in the science fair was nominally voluntary, but some teachers made it mandatory for their students. There were teachers who volunteered for the fair, but others, those who ran it, did so by mandatory lottery. *This practice is dying*
off now that the department has a new chairperson. The majority of teachers just do not see the value gained from science fairs. She agreed, saying, it was too much work, and the quality of the projects was not worth the time. Field trips are very important, she alleged, but they are limited by budget constraints. She believed that parents are not involved in school activities even though they are always invited because the majority are low income, and work more than one job to make ends meet. This makes it hard for them to make time to visit the school unless it is for something very serious.

**Part IV. Teacher’s teaching and learning experience in science.** The topics that Ms. Williams’s students seemed to like were genetic engineering, genetics, evolution, and ecology. They seemed not to like biochemistry, cells and cell biology, DNA and protein synthesis. Students have had very low test scores. It is hard for them to visualize what they cannot see, she explained. And, Vocabulary is a challenge for them, and they do not study or do homework. In physical science students were interested in ecosystems, energy, tectonics, volcanoes, and earthquakes. They did not like the rock cycle and geology. They did not care about these, she concluded. The population unit was too long and drawn out. Some changes might be made for the next school year on this. Her comment on STEM/STEAM was that in the future careers would be in STEM fields, and she could not stress that enough to her students. Those few motivated students know the importance of STEM, she said. And I wish it was the majority.

**Part V. Interest/motivation/attitudes to science.** Ms. Williams started this section by saying that those students who are interested in science will ask questions in class related to what is current. This could be something they heard on the news or it could relate to in their daily lives. She had not noticed any difference in interest by
gender. Her MYP biology classes had more girls than boys. In this past school year she had only four boys—that was roughly 56 girls and just 4 boys. With that, she said, *I could give girls credit for interest in science based on their numbers in this track.* She continued, *this past school year one of my MYP classes had extremely quiet students,* something I had never seen before. She described that the entire first semester the kids did not say anything, no matter how much she tried to engage them, but they came along little by little in the second semester. Looking at who was interested in science, it was difficult to sort out. There were times when she had boys, even though it was a small number, but they were more interested in what was happening than the girls, particularly in these high performing tracks like honors, AP, MYP, and IB. She elaborated,

I always encourage my regular track to register for honors classes, because some students cannot handle the behavioral problems that are typical in regular classes. They think that honors classes are too hard, but I encourage them by telling them that honors classes use the same syllabi, it is only that they [the students] work harder.

She feels that interest in science decreases with age because she has taught all grade levels, and the interest was a little bit better with freshmen than seniors. However, upperclassmen hardly enroll in science courses unless they have not taken the required number for graduation. Given the fact that the school is a magnet for performing arts, most upperclassmen would be concentrating on the performing arts and making their final graduation plans. Her students mentioned wanting to go into physical therapy, nursing, and science teaching. These are higher performing students and IB students. The
rest of the students just want to graduate and find a job. She answered the question about curricula acknowledging that there was room for improvement, adding,

A better vertical alignment is needed for the curricula. Within the subjects we teach, we do have some say about the materials. Curricula are primarily guided by the NGSS (Next Generation Science Standards), BOY (Beginning of the Year assessments), and EOY (End of Year assessments). We will soon start NGSS assessment for biology. These assessments are controlling everything we do, regardless of the curricula.

Ms. Williams said that she tries to connect what students learn with their lives, but it was limited. That is what students always ask, “What has this got to do with my life?” If I come across something of particular importance about students’ ethnic groups, I share it with them. She motivate students by using video clips and chapter puzzles. She mentioned a Jurassic Park movie clip that she used at the beginning of a DNA structure unit.

The major misconception her students have had was their idea surrounding the fact that individuals do not evolve, it is populations that evolve. Students feel that if an individual is smart, has acquired a lot of knowledge, and is successful, it means that the individual has evolved compared to his/her peers with less of those qualities. The other misconception is also around human evolution. Their understanding is, often, that humans came from monkeys. However, after she taught her students about phylogenetic trees (cladograms), students realized that apes and humans have had a common ancestor, not that humans came from monkeys.
Ms. Williams did not answer the question about equity in her survey; she put a question mark on it. So I asked her about it during the interview, to clarify in case she did not understand the question. She was quiet for a while, and finally she said, “There is no way I would treat any student unfairly.” I asked her if she could elaborate, whether she may have had any complaints from her students, and how she made sure students treated one another fairly. She said that she could not think of such situations’ having happened in her classes, and her body language suggested to me that she was wondering why I would ask. This was the end of the interview. Ms. Williams had shared very important information about her students, and she too was frustrated when she spoke about her students’ lack of interest in science. She said that the MYP class that was quiet for the entire first semester had frightened her.

In conclusion, Ms. Williams showed her frustration about her students’ lack of interest in science, but she spoke about it more as a concern than as mere frustration. She seemed to believe in the students—that something good will eventually come out of them as they grow older. She was determined to continue the struggle of putting science at the forefront for her students.

Henryk Zubek. 7/22/2016, 6:00 p.m.–7:00 p.m.

Part I. Teacher’s demographic information. I interviewed Mr. Zubek at a Starbucks café in his neighborhood after the workshop. I thanked him for agreeing to have the interview on a Friday evening after such a long day. Mr. Zubek was a Caucasian man of Polish descent in his 60s. He was over six feet tall, and had a great sense of humor. He held a master’s degree in science. He had 28 years of teaching experience, and out of these, 24 were in science. He currently taught only physical science, but in the past
he had taught math. Mr. Zubek came to the interview with his wife, a retired grade school science teacher.

**Part II. Teacher’s personal attitudes to science.** Mr. Zubek’s interest in science started in high school. It was inspired by his teachers, who made science appealing and became his role models. This direction was reinforced by his having a “low-level command of English,” he said. In college he had majored in physics, and he worked as an engineer before he switched to teaching. He said that science is very important to students because it gives them a better understanding of the laws of nature and teaches them how to think analytically. On the question of whether or not administration supported science, he answered, *I suspect they do, but I’m not sure how they manifest it in ways different from other subjects and departments.*

**Part III. Teacher’s school information.** Mr. Zubek’s survey had many gaps. I asked him if he might not have understood the questions. He responded by making some jokes; he was a very witty man. I explained to him that we would focus on those questions that were not fully answered in the survey. I went on to ask him what he thought about the parents, and he said, *I did not want to write it because it would look really bad, but the truth is that I hardly know them. No matter how hard I have tried to ask them to visit the school for various reasons, they never came, not even for report card pickup days!* He also said that student attendance was a problem for his first and last periods. A lot of students walk their younger siblings to their own schools before they come to school, and at the end of the day they have to leave early to pick them up. He continued, *there is really nothing that can be done in such situations, because the parents work, and these older kids take parental responsibilities.* His students were grades 10–12,
all in regular tracks, and some classes he co-taught with special education teachers. Mr. Zubek offers his students science fairs for extra credit, but the participation is minimal. As for science clubs and field trips, he said that he does not sponsor clubs or take students on field trips. *I don’t utilize field trips or clubs; I find the logistics too cumbersome in terms of money and time—they outweigh the benefits.*

**Part IV. Teacher’s teaching and learning experience in science.** For the questions about life science, which Mr. Zubek was not teaching, he decided to ask his niece and the niece’s boyfriend, who were in high school in different schools. Those two said, “Anatomy and cell structures are boring and they suck.” He does teach physics and chemistry, and he also asked the two teenagers about those subjects. His niece had taken physics and environmental science, and she said that “physics sucks” but environmental science is “fine.” The boyfriend said that chemistry/periodic table and geology both were boring and a waste of his time. Speaking of the students he taught, Mr. Zubek said that everything varied from day to day. At the beginning of the year he taught them math because, he said, *I am convinced you can’t be a good scientist without being a good mathematician.* He added that the STEM/STEAM that everyone is talking about is important, but students have to buy into it.

**Part V. Interest/motivation/attitudes to science.** The question here was whether students are interested in science. Mr. Zubek thought that *students were interested in science at the same level of their interests in other subjects.* The problem is that *they are not willing to spend time to learn and do it.* He said that he knew what honors, AP, and IB classes are like, because he had a chance to teach some of them in the past. *Those students seemed more capable and ambitious than those in regular classes.* He did not
observe gender differences in science interest, though he said that with girls it was a little bit better because he was still able to “bully” them to do some work. The boys he could not “bully”: once they refused to do something that was it. He also could not tell whether interest in science increased or decreased with age. He felt that to examine that would require analyzing the whole K–12 to see how interest changes as student move up the ladder. His wife said that her grades one and two were very excited to do science, especially doing activities.

Mr. Zubek said that he did not like the idea of teachers being asked to motivate students. He preferred engaging students, because he wanted to put the responsibility on students. Eventually it is up to the students no matter what the teacher does, he said. He further reported that his good students are girls, adding that college statistics have for a long time shown enrollment rates of 60% female students compared to 40% male. He said that he had started telling boys, Very soon women will rule the world and men will have to take some steps back. He continued to talk about boys: Every now and then I get one or two boys who seem to know everything, but not very often. He added that when kids do paid work after school for long hours into the night, it robs them of time to focus on their education, but [solutions for] these are beyond what a teacher or school can do.

In matters pertaining to careers after college or after high school, he said, I ask every year strongly recommend that they should choose a career—not necessarily one that requires them to major in science—and work towards achieving it. He said that students will say, “I want a career in a medical field” but not know what it would take to achieve that. He further explained that his teaching style is different from other teachers. He approaches the curricula differently. He tries to expose students to as many concepts
of my subjects as possible, because students are taking these courses as introductory courses. What is important is exposure. This way they might develop interest out of this array of information and focus on that interest. If only a few concepts were to be chosen and then the teaching went very deep, students might be turned off. *Introductory courses’ focus is breadth, not depth*, he concluded.

Mr. Zubek spoke about equity. He said that he dealt with issues of fairness by not picking sides, but insisted on mutual respect from and for everyone in the classroom. Teaching physical science shelters him from science misconceptions, so, he said, he did not have anything to share on that topic. However, when it comes to beliefs and historical theories, he said that he tells his students that a *theory is right until a better one comes along*. Mr. Zubek’s wife was now signaling him that time was up for their parking meter. Fortunately, we were done.

In conclusion, Mr. Zubek provided very logical data on students’ interest or lack of it in science. He did not think that students of the past were different from the students we now have. He said that this is a phase, and a few years down the road the students will find something they like, science or whatnot, and follow through. He was a very witty man. His sense of humor makes him a really good teacher for inner city students. He seemed not to be frustrated by students’ lack of interest in science. His response to this question, said jokingly, was, *Compared to what, or when?* His long experience in teaching science in inner city schools has prepared him for students’ lack of interest, and he does not think that there is a big difference between today’s students and those of the past.
Mr. Drew Johnson. (No interview)

Part I. Teacher’s demographic information. Mr. Johnson was an Asian American man, 55 years old, who was about five feet four inches tall. He had worked as a science teacher for 31 years. He held a master’s degree in science education. He was not able to do an interview because he was out of the country on vacation at the time I was conducting them. The analyses below are based on his answers to the survey questions.

Part II. Teacher’s personal attitude to science. Mr. Johnson went to college to be an aquatic biologist. He then took up teaching to be able to pay for his graduate degree. He fell in love with teaching and never left it. He wrote that he had been interested in science ever since he was a little boy. Mostly he was interested in animals. Mr. Johnson said that science is very important for two reasons. He said, *I believe that science is very important in that (1) the students learn about how their world works in terms of science and (2) it teaches students logic, like how to think or evaluate situations.*

On whether the administration of his school supports science education or not, this was what he wrote: *Administrators do not emphasize science any more than they do any other subject at our school, it seems. They do emphasize that it is important for students to pass their classes.*

Part III. Teacher’s school information. For the question about parents and community support for science education, Mr. Johnson wrote that he did not know for sure, but they had not demonstrated that they were supportive. This could be because of the parents’ daily struggles to support their families as immigrants. He wrote about tracking at his school, *Apart from the regular, honors, and AP tracks, the school has an IB program and an Avid program that have their own schedules and curricula.* He wrote
that he does not sponsor any science clubs or take students on field trips. As for science fairs, he only has students do it if he is coerced. Otherwise, he would not do it on his own, because the quality of the projects students do is mediocre.

**Part IV. Teacher’s teaching and learning experience in science.** Mr. Johnson taught all the grades, from 9 to 12. In life sciences, he said that his students liked genetics, taxonomy, some evolution, and zoology. They liked to study about animals—how they became the way they are, how they live, what they eat, and so forth. He wrote that the majority of his students did not like stuff about cells, mitosis, meiosis, DNA and protein synthesis, or any chemical processes because these required some level of memorizations. Even when mnemonic devices were provided to help them learn certain concepts, they seemed not willing. He also taught physical science, and he wrote that students did not like rocks and rock cycles. They felt that these topics were boring. Chemistry students did not like any lesson that involved calculations like radiometric decay, half-life calculations, or stoichiometry, because they did not like math either. How important is STEM/STEAM and why? Mr. Johnson wrote the following:

I think that any program which tries to increase the interest in science and promote ways of teaching science is important. For me, it may mean teaching a certain topic in a different way that may reach the students by increasing their interest. It may be the difference that pushes a student into a science career.

**Part V. Interest/motivation/attitudes to science.** The question was whether his students were interested in science or not. Mr. Johnson wrote the following:

I believe that students are still interested in science, but I believe that their learning behavior has changed. They live in an age where everything is given to
them, they have everything that they need, and [think] everything should be given right now.

_Students approach learning differently; they want the answers to be given like “googling the answers on their electronic devices and getting them now._ He continued, students feel that _they should not do any strenuous work to get the knowledge, and any strenuous work is not worth the effort._ He wrote that students prefer to do lab experiments, but again, writing up analyses and evaluations is too much work for them. They think that _doing a lab is enough work, and a teacher should give them full credit._ As far as gender and interest in science are concerned, he did not think he had observed a difference by gender. He wrote that the topics students are interested in, like the planetary system, earthquakes, and volcanoes are of equal interest to boys and girls. In chemistry, both girls and boys like the wavelength activity because they are involved in the production of the color spectrum. For students, _seeing those colors is exciting, but getting into the details of why the colors appear as they do is not._

Does students’ interest in science increase or decrease with age? On this question, Mr. Johnson wrote, _I think that their interest decreases because as they move up in grade levels science courses become more demanding. Most of them do not want to calculate mathematical tasks, but as they continue to evade math they find out that math does not go away, and they then choose to give up._ He wrote that teachers have tried to help them catch up, but they did not _want to think more than they had to_. When he asked his students whether or not they would choose careers in science, the majority said that they would not. Those who said they would mentioned that they would be nurses or work in medical fields. He explained that even students who had shown interest in science would
wonder how demanding science would be in college, and a lot of them said they could not give their whole life to science. So they would not be scientists or pursue other scientific careers.

Mr. Johnson wrote about the curricula. He felt that the curricula were good, but could use a better sequencing. He felt that the administration had their own interpretation of curricula, and department chairs were responsible for sharing information with staff. In the science department teachers who taught the same subject decided what they would teach each quarter, and that was how it was done. He addressed the question about tapping into students’ knowledge. This was what he wrote.

I always do [that], because I am a bilingual teacher, and that is one of the strategies that have helped me reach my students. Etymology of words helps make connections to students’ language, cultural events, food, and money/currencies, [offering] many examples to demonstrate certain topics being covered.

Mr. Johnson detailed ways in which a teacher could be effective in motivating students, which tied back to the last question about students’ cultural/ethnic knowledge. This was what he wrote.

It is always useful to try to tie in the subject with anything relevant to their lives any chance you get. Topics that interest students vary all the time. A teacher must do an interest inventory in the beginning of the school year to get an idea of what interests the new group of students bring.

He mentioned some of these inventories that he collected from students. He said that video games, comic characters, cell phones, food, fashion, and money happened to be
concepts he used to connect with his students in his teaching. He wrote that in some years some of these worked, and in other years they did not work, and that was why an inventory was necessary at the beginning of the year. Every group is different, and they are able to influence each other positively or negatively. He also suggested that using this technique could help students develop new interests.

Mr. Johnson did not write about the issue of equity in his teaching. It is possible he did not understand it, and since there was no interview, I could not clarify it with him. I tried to send emails, but did not get any response. Maybe he was not checking his email while on vacation. He addressed the issue of theories that might be the basis for stereotypes, stigmas, and prejudices in education. He said that students are conflicted around the theory of evolution because of their religious beliefs, and that he always encourages his students to approach learning with an open mind. He also tells his students that even when people choose to disagree on something that does not make whatever it was they disagreed upon wrong or false. In science there are methods of investigation to seek an explanation based on hard evidence. Religion is based on beliefs, and everyone has their own religion and their beliefs are different. He told his students that in science you can make claims, but you must have evidence to support your claims. Otherwise, that would not be science.

Even though Mr. Johnson did not do an interview, he provided very rich data on the survey. His technique of taking students’ interest inventory is a good method, one that could be used by other teachers.
Mr. Jose Sanchez. 7/24/2016, 12:00 noon–1:30 p.m.

**Part I. Teacher’s demographic information.** Mr. Sanchez was a Puerto Rican teacher aged 37. He stood about 5 feet 5 inches tall, and looked very young for his age. He’d had 13 years of experience as a science teacher, and had a master’s degree in science education. We did an interview during lunch time at his favorite restaurant. He is a regular customer at this place, and was comfortable asking the manager if he could lower the volume of the music because we were recording our conversation. The manager turned it off. I thanked Mr. Sanchez for turning in the survey and coming in for the interview. As we sat talking in a far corner of the restaurant, there were very few people around, and everyone who came in was given a table away from us.

**Part II. Teacher’s personal attitude to science.** Mr. Sanchez was a high school teacher. He taught all grades, 9–12. He had a bachelor’s degree in biochemistry, and teaching was his first job after college. He had started by teaching GED for one year, and then he got his teaching certificate and moved into teaching high school. He said that he had always been interested in science from his early years. He used to watch nature shows on television. His dad was a retired high school counselor, and his mother a retired high school science teacher. He thought that *science is important because it teaches students how to think critically and systematically.* He said that *the administrators of my school have no interest in science at all. They use science rooms for other subjects, and they put air conditioning in other classrooms but none in science rooms.* But he amended this during the interview, saying that he has been in the same school all his teaching years—13—and has gone through a number of administrators. Some of them had been *supportive of science, but the current ones were the worst.*
Part III. Teacher’s school information. Mr. Sanchez’s school is located in a big city in a Midwestern state and is considered an inner city high school. This school had about 1,050 students this past school year, but its capacity is 1,500 students. The school statistics at the time of this study were as follows: 93.1% low income; 19.4% diverse learners; 25.5% limited English proficient; and a 24.2% mobility rate. Student population ethnicities were as follows: Hispanics 73.0%; African Americans 12.6%; Asians 7.8%; Whites 5.1%; and Others 1.5%. The makeup of all of his classes were a representation of the school ethnic groups. The school is situated in a low income neighborhood and the parents are mostly high school graduates or uneducated. The parents and the community do not necessarily support the school unless there is a serious reason for their attention.

The school practices tracking; offering regular classes, honors, and AP. Mr. Sanchez has taught all three categories. There were two clubs. One, the Science Honors Society, was run by a science teacher. The other was a bee keeping club run by a science teacher and other non-science teachers, but any interested student interested could join. “I do not run science clubs, but I have a martial art class kind of a club that students attend after school,” he said. Some science teachers take students on field trips, but these are very limited due to funding limitation. Mr. Sanchez himself had not taken students on field trips. The graduation rate ranged 63% to 65% from year to year. The rate for 2015 was 77% (finished within four years) and 79% (finished within five years).

Part IV. Teacher’s teaching and learning experience in science. Mr. Sanchez taught both life sciences and physical sciences. In life science, he said, students found genetics and ecology more interesting compared to the chemistry of life or cell biology, which required memorization. He said, this past school year I was surprised how
interesting stoichiometry was for my students, something that had never happened before. In general students did not like chemistry. They did not like Earth/space science either, and said it was very boring. He said that STEM is very interesting to him because he knew that the future will depend on it. Unfortunately, he said, for my students it will probably take a few more years for them to realize what we (teachers) have been telling them. The majority of students will not go to college or into a trade that would help them enter into STEM fields.

V. Interest/motivation/attitudes to science. This was Mr. Sanchez’s response to the question about students’ general interest in science:

I think that students are interested in some aspects of science, but not in school or learning as a whole. Students come to school to socialize, not to learn. My dad told me this the moment he knew I was going into teaching. Of course, I did not believe him completely. I thought I was going to motivate them and they would be excited to learn. I am glad I never said anything to him—otherwise I would have to eat my words.

He had not observed any difference in interest between boys and girls, but as far as interest increasing or decreasing with age, he felt that both applied. Students who are serious with their education, those who are heading to college, will have their interest increase. But in those who do not like science and have no plans for college or a trade, the interest will decrease with age. He asks students about their future plans, though not specifically for science, but he has heard those who said they would be engineers or make careers in medicine. Recently he had received good news out about two of his students who had not been in his classrooms but had been in his kung fu club after school. One
was in college majoring in biochemistry and the other one was majoring in biology. They both told him that they never had any plans for college until they joined the *kung fu* class. Another student of his who had just finished an engineering degree had also been in the *kung fu* group.

Mr. Sanchez spoke about curricula, saying that the curricula were designed by teachers using the Next Generation Science Standards. He used the 5E (Engage, Explore, Explain, Elaborate, Evaluate) method of instruction with a great deal of inquiry and humor to motivate his students. He said that he was very popular with students because of his good sense of humor, and that was where equity came in for him when he taught. Students related with him freely, and they worked even when they didn’t know what they were doing because they wanted to go with the flow as he walked around telling jokes. I asked Mr. Sanchez how he maintains balance in his classrooms, telling jokes and at the same time making sure that students are engaged. He explained to me how he did that.

With teenagers, the first thing for them is to see if you care about them as individuals. Teaching comes later. Teenagers are very emotional and selfish people, and they want to be acknowledged as individuals. I am the director, they are the stars. Female teachers can do what I do, but a lot of our students have no male role models in their lives. I saw how I got such a connection with students during the after school *kung fu* club.

When he met students outside of school they would run to him and act the way they acted with him in his classrooms. But he would not act the same way out of school. The students would be confused, thinking that they might have done or said something
wrong that displeased him. To help students understand, he had to address this in all of his classes.

I am a character [he told them], but not a fake character. I am a comic when I teach, and out of the classroom I am the other part of me. I cannot say or act the same way [inside and outside] the classroom. So students get the message, and when they see me outside the school they greet me and talk to me like they would any other person.

When he taught evolution, a student might shout, “I don’t believe in that.” He would respond, “I am glad you don’t.” That is, he taught students that before they go against or go for something, they needed to understand it. This way they are able to argue with evidence for it or against it. When students used their popular saying “I don’t come from monkeys,” he would then make a lot of jokes. Not every teacher can do this, only me, he said. And then he would go on to tell them that nobody who was educated would ever say something like that. Once he had done all the jokes, it made the students interested enough to hear the truth, and he could then teach them the correct theory behind all those misconceptions. Mr. Sanchez said that teenagers’ attention span is very short. They do not want to know the details of anything. All they want is shortcuts. “Give us the answer!” they would yell. So, it is important to find a way to get them hooked, and that is when my jokes come in. I can lead them to a point where they can listen to the story behind their misconceptions. Now we were done with the interview. We thanked the manager for turning the music off for us.

To summarize, what Mr. Sanchez does in his classrooms is unique. Just like Mr. Nash’s approach, it is not something every teacher could do. His teaching style
demonstrates how special every teacher is. The qualities and techniques of teachers are unique to each teacher, and they cannot be easily taught. Mr. Sanchez’s comment on the advantage of being a male teacher rather than female is valid since many students do not have male figures at home. Female teachers are representations of the mothers.

Meesha Coleman. 7/20/2016, 4:00 p.m.–5:00 p.m.

Part I. Teacher’s demographic information. Ms. Coleman was an African American teacher in her 60s. She was about 5 feet four inches tall. She was a very pleasant lady eager to share about her teaching as a special education teacher in the science department of her school. She had been a teacher for four years. She had a juris doctor degree before she decided to go back to school to study special education. We had the interview at the back of her car. She had backed into a parking space in the university parking garage, and she opened the trunk and we sat on its edge. As we were facing the garage wall, this gave us some privacy.

Part II. Teacher’s personal attitudes to science. Ms. Coleman said, *I was never interested in science* before she changed professions and went into special education. *I was placed in the science department the day I reported to work.* It was from this placement that *I knew I had to study science seriously if I would be of any use to the students. I did not know I would like it, but I do.* She said *that science is very important because it answers questions about the world in which we live.* She continued to say, *I am very lucky the administrators at school are very supportive of science; they were science teachers prior to their administrative positions….They attend science department meetings, and send science teachers for professional development outside of school.*
Part III. Teacher’s school information. The school is located in a big city in the U.S. Midwest. It is a small high school with 329 students, made up of 68% African Americans, 21% Hispanics, 7% Whites, 2% Asians, and 2% biracial. 98% of students receive free lunch. Ms. Coleman did not have enough information about parents’ education to be sure about it, but judging from those she had met and what students had told her, she could conclude that the majority of parents were high school graduates. Very few of them were involved in school matters. The few parents she had met during report card pickup or when she had called them about their children’s performance were very transparent. They would tell me that I should not send any assignments home because they could not help their children on assignments they themselves could not do. Some of her parents felt that at high school level they should not be helping their children with homework. The teachers should make sure that the students could do what was given as homework, or not give homework at all. She said that she appreciated parents’ honesty. Ms. Coleman did not sponsor any science clubs, nor did her department sponsored any. She did not take students for field trips or sponsor science fairs, as science fairs were not the practice at her school.

Part IV. Teacher’s teaching and learning science experience. Ms. Coleman taught life sciences. The parts her students liked were dissecting and, a little, genetics. In general they complained that the content was boring and had no use in their lives. In chemistry, students were very shocked and disappointed that they were not doing labs that involved chemicals; more importantly, they wanted to see something explode. So, since students liked to dissect, her classroom teacher and she told students that dissecting
would take place at the end of the year, and only for those who would maintain good grades and behavior. This was how she put it:

> We hold dissecting over their heads as a bargaining chip for them to do anything at all. If you don’t participate in this or that you will not get to dissect at the end of the year. But it gets to a point where some give up even the dissecting.

She said that she understood the importance of STEM, especially its value in solving problems using critical thinking skills. *My students need to feel that they have some control over decision making, and it is not always possible.*

**Part V. Interest/motivation/attitudes to science.** Ms. Coleman said, *my students are not interested in science at all. Some did not pass the classes because they did not participate, and some did not attend enough to pass and then would be surprised that they had to take the class again to graduate. Their thinking was that we would just give them Ds and go on like that until they graduated.* She noticed that boys were not shy, so they would choose to try to make some connections to what was being taught, even though sometimes they wanted to do it because the teacher wanted someone to say something. They could be completely ridiculous, but they would say something in class. The girls, on the other hand, *are very quiet and even embarrassed at the things the boys would say or ask us.*

She was surprised that freshmen came in thinking that they were repeating what they had already learned in middle school. However, they were not able to explain what or how they knew what they said they knew. She did not think that students’ interest was increasing. She thought that it was decreasing, because *as the kids got older they added negative attitudes toward learning.* Her students had not said they would be interested in
science if they were to go to college, but she had had two girls who went to college to become nurses. *Students do not feel like they should listen to us (teachers) talking about college, because they ask us why they have to take science in the first place.*

She said that she had a lot of say about the curricula, but the results were limited because of funding. She tried to motivate students to enroll in post-secondary courses even if they did not want to *waste four years in college.* She encouraged them to go to community colleges and enroll in courses of their choice. The majority of students wanted stable jobs after high school. She told them that those jobs are limited and they pay minimum wages. When she sat down with her general education teachers, they tried to design lessons that would pertain to certain aspects of student culture. For example, in physics, where students could move a little bit when they did certain activities, they used sports as part of the lesson. Hispanic students played soccer and some played baseball, or they had role models in those sports. They used basketball and football because Black students had role models in those two sports, they liked those two, and some played them. Students had misconceptions about science. For example, “They believed that Black people do not work in science fields.” She dispelled such myths by naming Black scientists and what they had accomplished.

Ms. Coleman said that she gave two talks to her students. One talk was about college and the other one was about jobs. She said that out of 50 students she would have at least three students who had made their minds about going to college a long time before high school. So, she would ask the classroom to give her a chance to say something to these few who aimed for college.
Science is important for everybody’s life even for those who do not like science because when you get sick you go to the hospital to see a doctor. You go to see a dentist to check your teeth and you have your teeth cleaned. You go to have your eyes checked, all these are people who studied science. Everything you will do, eat, play with, drive, science is involved. So those who plan to go to college please make sure you see your counselors, and visit college and career center, so that you get information about college, about scholarships, about what type of ACT scores that will get you scholarship money and many more stuff.

Those few students who are planning for college or are willing to listen and would pay attention to the talk shook their heads to show agreement. The second talk would then follow, she would say the following.

You need critical thinking and problem solving skills to be successful in anything you will do in life. Some of you have asked me about how you can get a stable job after high school. Many jobs will depend on STEM, and the majority of these jobs are not around yet. You don’t want college that is you, but you need to develop some skills, so choose what you will do with your life carefully. Please visit the college and career center and get some information.

During genetics she had a lesson about sickle cell disease, which affects people of African descent. She knew that students would have heard of this condition or had first-hand information from family members about it. She thought this would answer the students’ question why do we have to study science? And their belief that science has nothing to do with my life. When she explained that the chances of a Black child’s being born with the disease is one in 365, and that one in 13 carry the trait for it, the students
were not necessarily impressed. She also informed students about African American scientists and inventors. Her approach went like this:

Do you guys know who discovered the super soaker (water gun)? Do you know who the real McCoy was? So, I told students about these people. Some students knew the phrase the real McCoy but they did not know it had anything to do with a Black person. So I explained to students about these two great men and a lot of others who have done a lot of good things other than the entertainers and athletes. Don’t get me wrong, I would say, these are good professions—entertainers and athletes—but I want you kids to know that there are plenty of Black people and Hispanic people and women who are great scientists.

The last survey question in this category was about myths, stereotypes, stigmas, or prejudices that might arise from old scientific theories. Ms. Coleman said that when she teaches evolution some misconceptions come up, although in her school they spend barely a day on evolution. When students start saying stuff about religion being against evolution or being related to monkeys, she always tells them that she could push back to single celled organisms—bacteria—and make a statement about bacteria being related to humans. Students laugh at that because they cannot imagine how a bacterium could be related to a human. Unfortunately they do not spend enough time on evolution to clarify all the myths and misconceptions.

During our interview, Ms. Coleman had stopped two times to speak to her son by telephone. It was now 5:00 p.m., and she needed to make one more call to her son before she left. I thanked her and asked if she wanted me to stick around so that we could leave the parking lot at the same time, but she told me that she would be okay. So, I thanked
her again and promised to be in touch and left. Ms. Coleman had a strong message to her students, and she provided rich data for me.

In summary, Ms. Coleman was very enthusiastic about what she does. She knew that the majority of her students had made up their minds that science was not in their future plans. However, she was very driven, and felt that as a teacher she had to continue to encourage her students to include science in their future plans. She said that she was a good example of those who had had no future plans for science, and yet here she was a special education teacher who had taken upon herself to study science rigorously in order to help her students.

Mr. Paul Thomas. 7/22/2016, 12:00 noon–12:45 p.m.

Part I. Teacher’s demographic information. Mr. Thomas was a young Caucasian teacher, the youngest among the participants at only 24 years of age. He was about 5 feet 5 inches tall and was very ambitious. He spoke very fast and had a strong command of English with a vast vocabulary. He had taught for only a year and a-half. He held a bachelor’s degree in chemistry. He was very proud to be the first person in my family to earn a college degree. His parents graduated from high school and worked in factories until they retired. I thanked Mr. Thomas for doing the survey. We were meeting for the interview during lunch time at the summer workshop. Two rooms had been reserved for the workshop, but we used only one for the sessions and used the other for keeping the instructional materials. The workshop presenters allowed me to use that second room for my interviews. They granted me 15 minutes extra for lunch time if I should need it, to return to the workshop by 1:15 p.m. That was really nice of them.
Part II. Teacher’s personal attitudes to science. Mr. Thomas said that he went to college to become a science teacher. He said, *I always felt connected to science, and the best avenue for me to pursue that was through teaching*. Science teaching is Mr. Thomas’s first job after college. He said that he was interested in science for as long as he can remember. His family’s house had a big backyard to play in with his cousin and one friend. They built all sorts of things and they did all kinds of experiments. His parents never put a limit on him. He said that *one time we tried to build a zip line, and I fell from it but I was not hurt enough to need medical attention or to let my parents know what had happened*. He said that science was very important to him because *it is a cog in society a link between subjects*. He said about his school administrators that they *give us free rein to teach what we want or get what we need, but they aren’t engaged in the practice*.

Part III. Teacher’s school information. The school is located in a large city in a Midwestern state. It is of medium size with 850 students. Eighty-five percent of students are Hispanics, 15% are African Americans, and 96% of students receive free lunches. The majority of the parents are first or second generation immigrants. He said that the school gets support from the community via an organization called Enlace, but there is not much support from parents. The school does not have science fairs or science clubs, but has limited field trips. The school practices tracking, and Mr. Thomas teaches MYP and IB tracks.

Part IV. Teacher’s teaching and learning experience in science. Mr. Thomas taught environmental science, Earth/space science, and astronomy. He hoped that he would get the subject he spent time in college to learn—chemistry—in the next school year. His students were mostly interested in astronomy. *I also like to teach astronomy as*
a topic to introduce to students to how science is done, by using evidence….For example, nobody was around when the Big Bang happened, but scientists have used evidence to show that it happened. He said that his students do not like to study cycles of matter. He thought that this is because their previous teacher quit on them in the middle of the year and because the teaching methods used were traditional ones. The students were cutting class until I started to use NGSS teaching methods and got a few back who heard about the changes. NGSS does not support teaching lessons that require too much memorization. It encourages allowing students to think critically and to take ownership of their learning. He said that there has been a few times when students were interested in learning, but the majority of the time they were not. He did not think this began in high school, but was a progression from middle school or even earlier.

By the time students get to me, they’ve lost a lot of their desire to learn science. I know that interest decreases with age—seniors do not care as long as they are passing. The curriculum does not help; ours desperately needs to be improved.

**Part V. Interest/motivation/attitudes to science.** Mr. Thomas said that he would love to see his students go to college, but that it was up to them I show them how they could successfully go to college, but eventually it will be left to them. The students’ after-school jobs take time away from their academic work. I empathize with my students, because I used to work after school, but it was to earn money to buy stuff for my backyard experiments. He understood that some of his students were working to help out their families. He also hoped that when he would be using NGSS teaching methods starting next year, the students might find science interesting. He does not teach life sciences, and there haven’t been physical science theories that were controversial with
the subjects he teaches. He does not think his students give much thought to the physical
science theories to begin with.

As for issues of equity, he did not answer this question on the survey. I asked him about it
during interview. His response was that he gets along with his students, and it was not a
long time ago when he was in high school. He believes that he treats all students fairly,
and thinks that his age helps him to relate to students better compared to older teachers. I
asked Mr. Thomas if he had any questions. No, he said, and allowed me to contact him if
I had more questions.

To summarize Mr. Thomas’s interview, he was young and had plenty of time
ahead of him to influence his students toward science. He was very energetic and showed
no frustrations with his teaching. He understood that some of his students had to work
long hours to help out their parents. He could relate to his students on working long
hours, but in his case it had been to support his hobbies, not for family maintenance.

Ms. Estella Armando. 7/20/2016, 12:00 noon–1:15 p.m.

Part I. Teacher’s demographic information. Ms. Armando was a young
Hispanic lady of Mexican descent, age 36. She was about 5 feet one inch tall. She looked
young enough to easily pass for a high school student. She had had 11 years of teaching
experience, the last nine of which were in science. She held a master’s degree in
education and social policy. I thanked Ms. Armando for answering the survey questions.

We had our interview during the lunch time of the summer workshop, using the same
side room I used with Mr. Thomas. Due to time constraints, I interviewed her together
with another teacher, Mr. Lazzaro.
Part II. Teacher’s personal attitudes to science. Ms. Armando was a history major who obtained an alternative teaching certification and began her teaching with a fifth grade self-contained class. *My principal asked me to pilot a new curriculum called FOSS (Full Options Science Systems), and that is when I fell in love with science.*

Growing up she actually *hated* science, and now she knew why. *I was taught science from a textbook—no labs and very abstract for me.* A year after she piloted FOSS, a university in her city offered a free science endorsement, and she decided to obtain that certification. The excitement she saw in her students was *infectious* she said. In her third year of teaching, her principal moved her to teaching sixth grade, and only science. And now she can proudly say, *I love science!* At the time of our interview, she was teaching science to grades six through eight.

Ms. Armando said that growing up as a child, her mother, a homemaker, took her everywhere. She visited all the museums and the aquarium and participated in outdoor activities, but none of those had interested her in wanting to study science. She does not think that the interest she has developed in science will ever go away. *I have not missed teaching history, and would not even want to teach it.* She said that science is very important because it is all around us. She wants her students to love science and to pursue careers in science. She was very proud of her school principal, who used to being a science teacher and is very supportive of science and science teachers. The principal departmentalized the school from third grade to eighth grade. She always makes sure that teachers have educational materials and allows them to share their knowledge with each other and to voice opinions in matters of science decision making.
Part III. Teacher’s school information. Ms. Armando teaches in a middle school located in a large city in the US Midwest. Her school has about 852 students of whom 99.9% are Hispanics of Mexican descent and 0.1% are African American. All students receive free lunches. The school graduation rate is 99%. Most parents are immigrants and have had very little education—the majority only elementary school. Despite these parents’ socioeconomic status, and despite being immigrants and non-English speakers, they are very supportive of science education for their children. The things the parents do to support science programs involved the following:

Parents participate in science night, which is when the children showcase their success stories about science. They allow their children to stay after school for science programs, they chaperone science field trips that are sometimes held on Saturdays, and they request workshops to learn more about the science curriculum that is being taught to their children.

The school does not practice tracking except for a few students who take high school algebra during an intervention period. Students participate in science clubs, field trips, and science fairs. Ms. Armando explained more about the parents’ contribution to the functions of the school.

If the school is in need of something and there is no money, the parents advocate to the alderman on behalf of the school. The school has created a strong culture with the community; it is an extension of the home. The bond between the school and the home is very strong.

Ms. Armando could not stop talking about how good the relationship is between the school and the home. The science night is not the only evening program; there are
nights focusing on other subjects as well. There is a very important celebration that brings the whole community together, called The Day of the Child (\textit{Dia Del Niño}). She elaborated:

Even though these celebrations are called \textit{night}, it does not mean that they take place at night. All the activities take place during the day, after school, to make sure that all students can attend. Older kids pick up their younger siblings from their schools and bring them to our school. These little ones attend all the celebrations at our school. Sometimes when we have after school activities, we have the little ones sitting and doing their homework, or we have some games for them to play. If we did not accommodate the younger siblings of our students, none of the after school activities would be possible. Our students would pick up their siblings from school and go home.

Ms. Armando said that the science fair used to be mandatory, but in the last school year they offered it as a voluntary after school club. She said that teachers are required to plan at least one field trip related to their content per quarter. The school pays for the buses to transport the students. She said that the school has a partnership with the Forest Preserve and there have been several field trips there to conduct “citizen science activities” (scientific research conducted by amateur or nonprofessional scientists. She added that the school used to have a partnership with a local zoo to conduct animal behavior observations, but it was discontinued a while back.

\textbf{Part IV. Teacher’s teaching and learning experience in science.} In life sciences, Ms. Armando said, her students like ecology. \textit{Specifically, they want to learn about invasive species and the impact they have on the environment.} They also like
evolution: they are curious about how organisms evolved and how to classify them. And they like cell biology and disease. They enjoy researching different diseases, their causes, and treatments. One unit the students did not necessarily like was the human body. Their reason was that the health teacher had taught it before, so when they had it in science class, it seemed redundant. Ms. Armando and her science department colleagues planned to eliminate it after this school year. In physical science, Ms. Armando said that force and motion are the most popular units with her students. She said that the unit on the application of Newton’s Laws of Motion using car collisions on ramps is very popular. The unit involves a lot of hands-on activities and is easy for students to relate to their everyday life. For some reason the energy unit is not very popular. What students told her is that the unit had been taught before by another teacher. A similar repetition had occurred with the unit on the human body in life science. What Ms. Armando thought should be done was to revise the syllabi to avoid repeating some units in multiple years while some units are not taught at all. Energy transformation had not been taught before, she said, and when she taught it, the kids were excited.

Ms. Armando said that STEM is very important because that is where the future careers will be. Some students “who do not excel in reading do excel in STEM classes, and it would be great if they would continue until they secure future careers in STEM.” She added that the earlier we introduce STEM to our kids, and if we stay with it as they grow, the easier they will accept it as a way of life. Students of color must understand that they have not been well represented in STEM fields, and it is our responsibility to bring this to them if we want change for their future. She explained, One way to expose students to science, especially STEM, is to take them to places where they can see STEM
in action….Science museums are a good example. Another means of exposure is to have students experience nature; like this summer my sixth graders will be going camping in Wisconsin.

V. Interest/motivation/attitudes to science. Ms. Armando’s students are very interested in science. She said that the school has built a great culture of love for science from grade three up to eight. Students’ love hands on activities, she continued. They love to discover and explore new ideas. They are curious about the world around them, and they are constantly asking about science clubs and science field trips.

Ms. Armando thought that girls still think that science is a boy’s subject. The boys are not shy about participating. They don’t care if they get the correct answer or not. They are willing to answer and ask questions even if they are not sure they know what they are saying. Girls in her classes are careful, wanting to get things right. They think before they speak, and they come out as winners, because they take their time to think things through. This approach is very important for both boys and girls, but the success is with girls. She added,

More girls show an interest in science. They have taken initiative in running science clubs and attending weekend science workshops and summer camps. They are the ones that apply for, and are interested in, science grants and programs.

She also noticed that students’ interest in science increased with age. Now, many of these older students, when asked what they want to be when they grow up, say astrophysicists, engineers, or name careers in medical fields. This was especially true of the girls. The girls are go-getters—they want to get out of the neighborhood and go to college. Another
interesting thing she mentioned was that when students were in lower grades and were asked to draw a scientist, they drew a man with glasses and a white coat. In eighth grade she asked them again—the same students—to draw a scientist, and this time they drew a woman. She asked the kids how come they had drawn a woman. Their answers were that they had depicted her and their other science teachers; the school had only female science teachers.

Ms. Armando was using a new curriculum called SEPUP (Science Education for Public Understanding) that she loved. She said that she could align it to NGSS as needed since she has input on what the department can add or remove from a curriculum. In motivating students, she uses students’ own knowledge by relating what she teaches to students’ lives whenever possible and appropriate. During advisory periods she talks with students to give them attention outside of the classroom setting and to have a more personal experience with them. The use of hands-on activities, small group activities, pop culture, and knowledge from their cultural backgrounds has helped her get students motivated and engaged in learning.

For whole-class discussions, she uses the talk moves method and the driving question board to discuss and dismiss misconceptions in science. In order to ensure equity in her classroom, she has built a family-like community based on respect, with the rule that everyone has a voice and the right to be heard in the classroom. In the study survey, Ms. Armando did not answer the last question about historical theories that might cause stereotypes, misconceptions, stigmas, and prejudices. During interview I asked her about it. She told me that the families of her school are very religious people. The majority belonged to a strong Catholic tradition, and some are Jehovah’s Witnesses.
When she teaches evolution, she makes sure that students understand that she is not trying to teach them anything against their religious beliefs. Rather, she is teaching them science topic, which is independent of their beliefs. To illustrate how religious the families are, she related that when she travelled with the kids to Washington, DC, which was a huge trip for everyone, parents sent with their children some saints’ figurines to give to her for protection of the children and herself.

This concluded our interview. She agreed to receive a call or email if I had questions. Ms. Armando’s data was very rich. She covered a lot based on the questions asked and added very important information. Having older students pick up their younger siblings and bring them to school where they were all safe and could continue with after school activities highlighted how a school is indeed an extension of the home and community.

Mr. Louis Lazzaro. 7/20/2016. 12:00 noon–1:15 p.m.

Part I. Teacher’s demographic information. Mr. Lazzaro was a 43-years-old Caucasian of Italian ethnicity. He stood about 5 feet 8 inches tall. He had 20 years of experience as a science teacher. He held a master’s degree in education. Due to time constraints, Mr. Lazzaro was interviewed together with Ms. Armando.

Part II. Teacher’s personal attitudes to science. Mr. Lazzaro said, as a child I liked to ask questions and seek answers, and science was a natural fit….My quest for science took me into reading mystery and science-fiction books, and I watched movies in these genres. He had also loved puzzles and detective stories. He said, Star Wars came out when I was a kid, and my interest in science was grounded. His seventh grade teacher was his role model in science. He was trying to make a lamp. He had some wires, and
when he put the bulb on [the structure], it exploded in his face. But he was not hurt. This made Mr. Lazzaro excited. He surprised himself by recalling his teacher’s name after so long. When he started teaching, he was supposed to teach reading and Spanish to fourth graders, but his coworker was not comfortable teaching science, so they switched. He became the science guy and has been ever since. He said that his students tease him, sometimes saying, not everything is about science, science guy.

He said that science seeks to explain the world around us, and the information is constantly changing. He loves that knowledge of nature has changed and evolved over time as we have continued to make new discoveries. There is always something new and interesting to learn if one seeks it in science. Science is the instructor of our daily lives. His school has a dual focus on language and social justice, so science has always taken a back seat to those topics. He said that he has made an effort to advocate for science and some of his coworkers have agreed with him, and the administrators have promised to give science some attention, if not a priority, in the next school year (2016–17).

**Part III. Teacher’s school information.** Mr. Lazzaro’s school covers pre-kindergarten through eighth grade. It is a dual-language magnet school located in a large Midwestern US city. The students’ population of 652 is broken down as follows: 84.5% Hispanics (very diverse), 10.1% Whites, and 2.8% two or more races, 1.2% African Americans, 1.1%, Asians, and 0.3% American Indians. Only 58.7% of the students receive free lunches. The school graduation rate is 100%. The parents of the students are mainly business people and city and government workers. He said the majority are college educated. The parents are very involved with the school. The school was started by parents who saw the need for their children to be fluent in two languages, English and
Spanish, and also to focus on social justice. The parents are very informed individuals who are always ready to help the school progress. In fact, the parents became involved to an extent that the faculty and staff found intolerable, walking into the school anytime they wished. Administrators had to put down some procedures to limit this. Mr. Lazzaro said that the fact is that this is not a neighborhood school. *It takes a lot of effort on the parents’ part to register the students, a majority of whom are bused in.* The school does not practice tracking, except for a few students who take high school algebra during an intervention period. There are no science clubs, either, because these would require after school hours to run them, which is not possible because the buses arrive to pick up the kids immediately after the last period.

In Mr. Lazzaro’s school every student participates in science fairs that involve research papers. But they are called *inquiry fairs*, so a student my choose a science topic, but does not have to. *Science topics tend to be popular with some students,* he said, *because it allows them to carry out experiments.* Students participate in field trips to museums, zoos, and aquaria. The seventh graders went on a three-day ecology trip to study sand dunes located just across the border in a nearby state. This excursion was very popular, and students did not want to miss it. Their study covered how the dunes form, what forces were involved in forming them, and their ecosystems. Another popular trip was a trip to their state capital. For a Washington, DC, trip the cost was $600 per student, of which the school paid $250 and the family was responsible for the remainder. The parents and teachers raised funds to make sure that every student was able to go.

**Part IV. Teacher’s teaching and learning experience in science.** Mr. Lazzaro teaches a number of units in life science, and his students like evolution. *They discuss it*
as if they could reanimate the dodo bird. In genetics they like talking about invasive species. He could not think of any unit that students did not like; their curriculum is applied science that students can easily relate to their lives. In physical science he teaches plate tectonics. They have also discussed what would be the best place to bury nuclear waste. Students like forces and motion units, such as when they discussed the best safety features in cars. He thinks that STEM education is very important because it goes beyond the topics covered in school and shows the students how to identify and solve problems in any situation and environment.

Part V. Interest/motivation/attitudes to science. Mr. Lazzaro thought that his students were very interested in science, especially the hands-on activities, which increases their interest. He saw a difference between girls and boys in this regard. He elaborated as follows:

Girls still think that they cannot do science. They are less likely to participate in class discussions for fear their ideas might be wrong. Boys, on the other hand, will share what is in their minds without concern about whether they might be right or wrong. Oddly, the girls tend to be able to explain their thinking much better than many boys.

Since he teaches grade six through grade eight, Mr. Lazzaro has the advantage of assessing his students’ interest in science. In his observation the level of interest has remained constant. Once the class got started and they saw that it was more than just reading and worksheets, the interest rose and kept rising. As for students’ future plans, he answered this question as follows:
When teaching, if I see a genuine interest in a career related to that aspect, I will spend time talking about it. Otherwise I don’t waste time talking about science careers to middle schoolers. Most of the students are concerned [only] about their next major step in life, which is to go to high school.

However, he does help his students understand what to expect in high school if they have questions. He has addressed high school issues like how things were going to be, how the teachers would treat them, and whether they would be able to handle that level of learning. *Those are the things I talk to them about, especially if they seem to be worried,* he said. Mr. Lazzaro noted that he is in-charge of the science curricula, and everyone is happy with it.

Since his is a dual language school, he said, they use knowledge of Spanish to learn the science vocabulary. They have a unit dedicated to the history of Native Americans, which is a social studies unit taught together with science. *Hands-on activities and relating the science concepts to students’ lives help to keep students engaged, and they like it.* To help students dismiss negative attitudes about science, he asks more questions, or he allows them to ask each other questions and he provide explanations. This allows for the students to be the experts and shows how it was okay to be wrong. When they see that being wrong was okay, it tends to diminish negative attitudes in the classroom. Fairness and equity in his classroom is approached by establishing norms that everyone can respect. *Confrontational language is not permitted, as shared opinions and ideas must be backed up with evidence—that is the truth about science.*
In evolution, he said, *I assure students that I am not telling them to believe in evolution, because science is not about beliefs; it is about evidence to support one’s claims.* When the kids have said that evolution includes assertions *like Humans came from apes,* he has told them, *using a statement like that would mean the same as saying that we evolved from dogs, or from any other animal.* The kids have good questions, and the teacher explains to them what the theory of evolution says and what it does not say, and the difference between facts and beliefs. This was the end of the interview. I thanked Mr. Lazzaro for his useful data, and he agreed for me to contact him if I had more questions.

To summarize, Mr. Lazzaro was not as outspoken as Ms. Armando during the time the three of us spent together. Much of the time he would keep quiet and let Ms. Armando explain, and then he would say he agreed with what she had said. I had to repeat the questions and ask him to explain in what ways their situations were the same. For example, Ms. Armando answered the question about parents’ involvement in the school by saying that parents had been involved to an extent beyond what the school could handle, and the school had had to limit it. Mr. Lazzaro said that it was the same in his school. However, when I insisted that he give his own explanation, it turned out to be similar but for different reasons. In Ms. Armando’s school, the less educated immigrant parents wanted to learn science just as their children were learning, and the school was not able to accommodate that. In Mr. Lazzaro’s school, the parents, who are from the middle and upper classes and had established the school, wanted to run the school’s day-to-day activities. In general their schools are very similar in terms of curricula and students’ motivation and interest in science. A notable difference is that Mr. Lazzaro’s
school does not have any after school activities like Ms. Armando’s does, since his is not a neighborhood school and children are bused back to their neighborhoods immediately after school.

Ms. Dominika Dombrowski: 7/21/2016, 12.00 noon–1:00 p.m.

Part I. Teacher’s demographic information. Ms. Dombrowski was a young, petite teacher, 25 years old. She was a Caucasian of Polish and Italian descent. She, like Ms. Armando, looked younger than her age. Ms. Dombrowski could have passed for a high schooler. She had been a science teacher for two years. She held a bachelor’s degree in science. I interviewed with her in the extra room at the workshop during lunch.

Part II. Teacher’s personal attitudes to science. Ms. Dombrowski’s interest in science started early in life out of her love of animals. She said, I thought I was going to be a vet, but I realized I loved children more and I could always have a pet, so I chose to be a science teacher. Science is very important, she said, because it helps children to know the world around them and why things are the way they are. In answering the question about whether administrators support science, she said, yes and no, and explained why that is the case.

There are extreme behavior problems at my school, so they are usually focused on that. But they support my needs as a science teacher. There are at least two fights on the third floor where eighth graders are every day, and the principal, the assistant principal, and security have to be involved in those incidents.

She opened up about the behavioral problems in school. As a student teacher she had taught sixth graders at this same school, and the students loved her very much. When she returned as a regular teacher, she had those same students as seventh graders for
home room. She was surprised how much they disliked her. Even in the classroom, the students behaved completely differently toward her, calling her names. When she asked other teachers for support, they insisted that the kids loved her and that their changed behavior was because now she was a teacher and had rules that they did not want to abide by. Her colleagues, the other teachers and administrators, gave her a lot of support. They believed that the students’ behavior change was also probably due to the fact that the students were used to teachers and adults walking out of their lives so frequently that they did not want to make any emotional investment in anyone.

She tried to look at the situation positively based on what other teachers and administrators had advised her. Unfortunately, things did not get easy. The name calling did not stop: she was a cracker, a White girl, and they accused her of being a racist. Very angry, she addressed this with the students, saying,

A racist will buy you pizza every month? This was after a student had spit at my face for no reason. I was sobbing, but I continued to speak. You know what, guys? I will quit like other people, and I will be able to find another job very quickly. I don’t think a lot of you understand that I know some of you will miss me, you will miss my teaching, what and how I teach you. And above all it will be the love I have for you that you will miss the most.

This happened on a Thursday, and she took a day off that Friday. When she came back on Monday, to her surprise, the kids were in a celebrative mood the moment they saw her. The kids had thought she was gone for good. They all promised they would never disrespect her; after all, they loved her so much. That was it, she was back, and she loved her students as before, and she realized her dream to work with African American
youth would come true. On graduation day she was in tears again to see her eighth
graders graduate and be on their way to high school. It was tears of joy this time, she
concluded.

**Part III. Teacher’s school information.** Her teaching site is a middle school,
grades six through eight. It an IB school located in a large city in the US Midwest. At the
time of our interview, there were 800 students, with 99% African American and 1%
Caucasian. Free lunch and graduation rates were 100%. Most parents had a high school
education. The parents are not very involved at the school, even when the school reaches
out to them. Science clubs are not popular. Ms. Dombrowski has a science club, but only
five students who attend it regularly. She plans to continue with the hope that she could
get more students later. Her school does not practice tracking. Science fairs are organized
as an after school, extra credit activity, and she said that it is very small group of students
who participate. She organizes field trips to the aquarium, the natural science museum, a
museum of science and industry, a water purification plant, and an electric energy plant.
These are recurring annual trips.

**Part IV. Teacher’s teaching and learning science experience.** This teacher’s
students like life science better than physical science. They enjoyed the cell biology units
because there were more labs, and the body system because they wanted to know how
their bodies work. They thought evolution was a little boring because it did not have
enough labs, but had many discussions about it in class and at the natural history
museum. Even though they did not like physical science in general, they enjoyed the
force and motion units because these two involved a lot of activities. The water unit, was
very uninteresting to them. They considered it too long and repetitive. Her students like
labs and other hands-on activities the most, but even with these, sometimes they become overly excited, especially boys, and destroy everything for everyone else.

Ms. Dombrowski considers STEM education very important, saying that she wants her students to understand math and science concepts so that they can excel in high school. She continued, *I utilize technology. I teach my students to use computer systems properly, and I am proud of this.* She is happy that she has taught her students an introduction to engineering which could help them determine if they want to pursue further education and careers in that field later on in their lives.

**Part V. Interest/motivation/attitudes to science.** Ms. Dombrowski can see that her students are very interested in science despite all the rowdiness, especially among the boys. She believes that they will grow out of this behavior and become very good young scientists. Girls are much better in controlling their excitement about labs, and they end up grasping the concepts better. She has seen that behavioral problems take away from students’ learning, and fears that as they grow older their lack of concentration on learning might get worse. Eighth graders spend too much time thinking about graduation and getting out of middle school over anything else. Those who have spoken of the future plans for their lives have always mentioned wanting to be doctors.

Talking about curricula, Ms. Dombrowski said that she loves her SEPUP curriculum, which she described as being complete and flexible. It is published by Lab-Aids. Its organization is such that six graders take Earth science, seventh graders take life science, and eighth graders take physical science. The curriculum comes with labs, reading materials, role playing activities, information on diverse learners, and a teacher’s manual which she said helped her a lot with physical science, which had been
intimidating for her at first. Teachers who had taught the curriculum for a while turned around and taught new teachers, and she said it worked very well because of the support system.

An IB curriculum at her school incorporates the cultural knowledge of different groups of students. Every year they assigned a country to a classroom, this the past school year her country was China. Students had to research how Chinese students learn. They had a celebration day where every class showcased their projects. When there are misconception in her classroom, she encourages students to discuss them with her until the correct answer is reached. She tries to accommodate students’ needs, especially those with IEPs. Hands-on activities, ethnic information on genetics, and the use of Google Classroom help motivate her students toward science. In genetics she teaches her students how people are different genetically. For example, in a class when they looked at certain traits, they discovered that she and all of her students have brown eyes. The students were surprised that their teacher had brown eyes like them. They also looked at other traits, like how many students could roll their tongues, how many had a hitchhiker’s thumb, a widow’s peak vs. a straight hairline, attached or hanging ear lobes, dimples, and how many were PTC or PTU tasters.

She told students that she is half Italian and half Polish, and asked them to go home and find out a little bit about themselves. She had asked them if they knew what part of Africa their ancestors came from, but the students did not know; they said that they were just Black. Slowly she found out that some of her students did not live with their parents. Some lived with their grandparents, aunts, or other family members. She realized that it was not easy for the students to do that kind of an assignment. However,
she discussed other things besides genetics that could help students understand the diversity among people. She used examples that were easy to understand. She told students, *On Thanksgiving I eat pasta at my house. What do you eat on Thanksgiving at your house?* The students shared their customs, finding that nobody ate exactly the same thing.

During the class’s evolution unit the majority of her students’ misconception surfaced. Some of them were about dinosaurs and about how humans descended from monkeys. Some students wanted information about how twins or other multiple babies were born instead of one. Ms. Dombrowski said that she did her best to explain these things in general and told the students that they would learn more about such matters when they go to high school and college. She said that evolution has been a difficult topic for her to teach, especially when students started comparing their features with each other and shouting, *you look more like a monkey than I do!* And things like that, leading to fights. She said that if she had a choice she would not teach evolution, because students can be very mean to each other. But, since she was in the middle of teaching it, she could not leave the topic with all the misconceptions and name calling without solving the problem as scientifically as possible.

She encouraged students to respect each other and only speak what was in their minds without making any comments about another person. In general students told her that their noses were different from hers, and their eyes were larger than hers, and many more comparisons. The teacher told them that the outside features might look a little different from one person to another or a group to another group, but the DNA which is the identifier of every organism showed that all people were all one group called
scientifically as *Homo sapiens*. She took the students to the field museum after the evolution unit. In there she walked the students to the exhibit that showed the evolution of man, this way they could learn the scientific facts. She showed them how the *monkeys* branched from the *tree of life* and where the humans ended. And that humans were the youngest organisms to evolve, so humans and *monkey* happened to have a common ancestor. She took them to the dinosaur’s exhibit as well since they had questions about them. She took them to see the geological time scale, and they could see when the dinosaurs appeared and disappeared. They also found out that Earth was 4.6 billion years old. I asked Ms. Dombrowski if she had any questions for me, which she did not, but would accept my calls or emails in case I had questions later. I thanked her for her rich data. Ms. Dombrowski was very honest about what had happened at her school, and how she was able to solve the problems by teaching the children the correct science facts. She provided very rich data.

**Dr. Enzo Fierro.**

There was no interview for Dr. Fierro. I waited at the chosen restaurant over half an hour before giving up. Later I learned that he had forgotten the appointment, but there was no time left for me to set up another. However, he had included extra documents with his survey to detail his accomplishments in and love for science.

**Part I. Teacher’s demographic information.** Dr. Fierro was above 60 years of age, a man of mixed ethnicity, he said, part Italian, with 39 years’ experience in teaching at levels from preschool to graduate school. Twenty-nine of these years were spent as a full time tenured faculty member at a teacher preparation university. He was the oldest and the most educated and experienced of the participants. His school is in a suburb, not a
city, but I made an exception to the sample criteria to use him as a participant because he has a lot knowledge about city schools and he has a vast knowledge of various areas of science.

**Part II. Teacher’ personal attitudes to science.** Dr. Fierro did not start out as a science teacher. He had wanted to be a chemist since he was seven years old. He got a bachelor’s degree in organic chemistry, and started work in that field. He was hired by the American Cancer Society (ACS) as a bench chemist even though he had contracts with the Food and Drug Administration (FDA), the Environmental Protection Agency (EPA), and the National Cancer Institute (NCI) as a head chemist. Later on his wife and he considered opening a home day care facility. Their daughter was then in a Montessori preschool. He decided to enroll in 0–6-year-old American Montessori training and was certified. For a few years he taught toddlers (18–30 months) and preschoolers (3–5 years). He then received an “unprecedented alternative 9–12 certification from the Association of Montessori International.” After five years of teaching Montessori elementary, he enrolled in the Master of Arts in Teaching (MAT) program at the National College of Education (NCE). With that degree, he got a tenure track position as a science coordinator and science teacher at the NCE laboratory school, a demonstration school. There he taught grades four through eight for many years, eventually joining the university faculty in the tenured position in which he currently serves.

Dr. Fierro’s early interest in science was sparked when he read an excerpt from Linus Pauling’s acceptance speech for the Nobel Prize for chemistry. Linus Pauling was, in a way, a role model for Dr. Fierro. Another was his grandfather, his namesake. He told his grandfather that he wanted to be an organic chemist like Linus Pauling. His grandpa
took him seriously and helped him explore the idea. They went to the library to see if this 
*Lionus Paul* had written any books. Indeed, he had, so this seven-year-old, now Dr. Fierro, was able to borrow a book by his role model. He tried to read it, but of course he could not understand it. However, his grandpa believed in him and encouraged him to pursue his dream when he grew up, which he did. Unfortunately his grandfather was not able to see him realize his dream: he died when Dr. Fierro was twelve.

Dr. Fierro said that he is recognized as an international expert on polychlorinated dibenzofurans and dioxins, Polychlorinated biphenyls (PCBs), and the synthesis of N-nitrosamines, among much other distinctive work. He said he has what he called the *dubious distinction* of inventing the pop in Pop Rocks candy, and at the university he is known as the *Science Guy*. He said that the importance of science to him is that you get to discover the secrets of the universe. *At this point I have synthesized 21 compounds that until I made them were never made in nature.*

On the question of administrative support for science, he referred to the period 1996 to 2002 when he had been the chair of NCE’s Science Education Department, which he believed to be the best in the Midwest. He said that the administrators of the University did not give the department enough support. He had tried to hold it together until 2011 when there were no more than five students registering, and it was closed out. After that, the university has continued to offer science teaching methods for teachers.

**Part III. Teacher’s school information.** As was explained in Part I of his data set, Dr. Fierro has taught at all levels of education. At the demonstration lab school, he taught middle school students. The school was located at a suburb of a big city in Midwest United States. This was a small school with 300 gifted students of diverse
backgrounds. Only 20% of the student population received reduced or free lunch. The parents were affluent people, and were very supportive of the school and the teachers. Talking about the parents, he said, *many parents after all these years tell me that I was the reason their child became a doctor or some kind of a researcher.* The school did not have tracking even though Dr. Fierro thought that tracking was probably a better way to teach science content. Students did a lot of activities that integrated art and science but not necessarily science clubs. Also he did not do science fairs because he did not think they were valuable, he did what he called science expo instead, whereby each student celebrated something they found fascinating in science. He did a lot of field trips to different places. The graduation rate at this school was 100%.

**Part IV. Teacher’s teaching and learning experience in science.** Biochemistry, evolution, and genetics were the most interesting topics to Dr. Fierro’s students. They were not very keen about taxonomy and cell biology. In physical science, students were interested in Dr. Fierro’s own work, and they did not like lessons that called for memorization. He is a strong advocate for STEM and has been a role model for students. He also advocates for STEAM, whereby the “A” represents Art. He added that a science curriculum could be enhanced by using the online DIY program Makerspace, which incorporates art.

**Part V. Interest/motivation/attitudes to science.** Dr. Fierro feels that students are always interested in science, *especially if a teacher teaches to her or his passion.* In emphasizing STEM and STEAM, he added, *Science curricula held hostage to textbooks standardized tests are the kiss of death to students’ engagement and motivation.* In his teaching, he always stressed to his students that science is gender neutral. Given that he
taught pupils from grade four to eight, he was a good participant to assess whether
students’ interest increases or decreases with age. He summed it this way: *I think my own
passion rubbed off on most of them during those years*. He engaged students in discussion
of their future plans in science, especially the eighth graders. He said that recently he had
received a copy of a dissertation from a former student who he taught in grades four
through eight. Getting this kind of information is not always a teacher’s experience.
Usually finding out whether students went to college and succeeded is an after-the-fact
event. Sometimes students promise that they will pursue science careers based on their
relationships with the teacher, but it is hard to know for sure if they have done so until
much later, if at all.

When Dr. Fierro was the curriculum designer for his school, he would improve it
as needed, but felt that it was very solid. He taught the children for many years, and this
made him a family friend to them. So knowing and including their culture in his teaching
was easily done. He motivated his students by sharing his publications and presentations
and his dissertation. Above all, he let them know that the responsibility for learning
resided always with them, regardless of the teaching. To help his students with
misconceptions about science they might have had, he listened to them and presented
rational scientific arguments. He said that he did not challenge students’ belief systems.
In matters of equity he said, *Well, I guess that is just the kind of person I am. Since my
students have been with me for multiple years, they know they can count on me to be fair!*

The last question of the survey was about theories from the past that might be
sources of stereotypes, prejudices, and stigmas in science education. Dr. Fierro addressed
such issues by doing a number of activities around the nature of science. However, if
students asked about his beliefs, he told them, *my beliefs are not what I teach. I teach science, which is independent of anyone’s beliefs.* This was the end of Dr. Fierro’s data. I sent him an email after I received the material to thank him.

In conclusion, Dr. Fierro has a vast knowledge of science and science education. That and his experience teaching in a suburban setting provided a different perspective compared to the rest of the schools in this study, which were all inner city schools.

**Data Analysis**

**Introduction**

All of the data to be analyzed came from the teachers participating in my study. Their data were sorted into 12 themes to compare and contrast middle school teachers’ data against the high school teachers’ data. These themes were organized in Figure 4.1 below using a Venn diagram. The themes of the Venn diagram were used as a tool for analysis triangulated with my own experience. In this section, unexpected data will be identified, and the chapter will conclude and foreshadow the final chapter.

I started the analysis by creating a table outlining the participants’ school type, gender, and race, for a quick reference.

Table 4.1

*Participants’ Demographics*

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<tr>
<td>Asian</td>
<td>2</td>
<td>9</td>
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The analysis of data followed the themes identified, which were then organized using a Venn diagram. See Figure 4.1.
Common Themes for the Participants

Age, race, experience, education level, teacher’ interest in science. The majority of the teachers in both middle and high schools were in their mid-thirties and mid-forties, and the majority were Caucasians. The majority were tenured and veteran teachers. All the teachers had master’s degrees except two who were also the youngest, who had bachelor’s degrees. The majority of the teachers had an interest in science since they were children. Some could not recall having been influenced by anyone, for example, Mr. Lazzaro, Mr. Thomas, Ms. Graeme (I have always been a science geek—for as long as I can remember.); Ms. Dombrowski, and Mr. Johnson (I was interested in
living things, and I thought I would be a vet, but realized I love children more). Mr. Nash said that he could not recall by whom or how he was interested in astronomy, it was just on his own. Dr. Fierro and Mr. Sanchez had role models who influenced them to like science. For Dr. Fierro it was his grandfather and a Nobel Prize laureate in chemistry. Mr. Sanchez was influenced by his mother, who was a high school science teacher.

Mr. Nash, Mr. Zubek, and Mr. Lazzaro had teachers as role models in high school who amplified their experience and interest in science. Mr. Nash said about his high school science teacher, I have never met anyone like him, ever! Mr. Lazzaro was hooked on science after his teacher had a lamp he was making blow up. Mr. Zubek’s interest came out of his circumstances: Science was a natural fit because of poor English proficiency. Ms. Williams and Ms. Dowdy grew up in environments that allowed them to experience nature, which drew them to science. Ms. Williams said that observing the butterflies her grandmother had collected increased her interest. My own interest in science as a young child developed similarly to Ms. Williams’s and Ms. Dowd’s. Farming and caring for animals gave me firsthand experience in science, even though it was unbeknown to me that it was science until later when I connected these early experiences with what I was learning in high middle and high school.

Mr. Thomas had a backyard to himself to do whatever he wanted, and he said that his parents did not supervise his activities, so he recruited his cousin and a friend to do science there. Mr. Lazzaro liked to watch science fiction movies and read that type of books, including comic books. He said that he grew up during the advent of the Star War movies, and those were at the center of his interest in science. Mr. Lazzaro added something else about his interest in science. He said that he used to ask questions of
adults and would demand answers everywhere he went as a child. Ms. Armando and Ms. Coleman’s interest in science was serendipitous. Ms. Armando said that she “hated” science when she was in school. This was interesting because her mother exposed her to everything that had to do with science, but her mind was focused on relating what she learned in school with her life. At school her science learning was what she termed old-school learning from textbooks and worksheets. (Dr. Fierro called this type of teaching methods the kiss of death). Once she started teaching and found herself thrown into a science classroom and saw the excitement in her students, she realized she had missed something important in her life. She was hooked on science from her students’ interest. Ms. Coleman was a lawyer who had switched professions to go into special education. As also happened to Ms. Armando, she was asked to report to a science room the first day on her new teaching job, and had not looked back to her old profession since.

School type, SES, graduation rates. All the teachers in the study except Dr. Fierro and Mr. Lazzaro taught in in schools where the families were of low income, low socioeconomic status. They were all public, inner city, neighborhood schools. Mr. Lazzaro’s was a magnet school whose children were bused in from different parts of the city. Most of that school’s parents were professionals and had higher levels of education. Dr. Fierro’s school was the only one in a suburb. The parents of its students were highly educated professionals and business owners with a high SES. Graduation rates in almost all the schools were high. Middle schools had almost 100% graduation rates. The high schools’ rates were not as good as the middle schools’, but were not too low compared to national averages.
Themes of Difference: Administrative and Parent Support

Middle schools. There was no tracking in the middle schools, and students were very interested and very motivated to learn. Administrators of the schools were quite supportive of science. Despite the behavioral problems that Ms. Dombrowski’s school had, she reported to have gotten great support from her principal, assistant principal, and fellow teachers. The parents of her school were not supportive of the school in general, but the other middle schools had established a strong relationship with the parents and the community. The parents of middle schoolers felt welcome at the schools and shared common interests with the school—the schools were extensions of the homes. Both Ms. Armando and Mr. Lazzaro had unusually strong relationships with the parents, up to a point where they had to set up some limitations because they felt it was interfering with the school functions. Dr. Fierro reported the same kind of parental support as the other two middle schools. He said that the parents were his friends.

High Schools. Most of the science teachers felt that there was no sense of community in their high schools. Ms. Coleman was the only teacher who reported that the principal of her school was directly involved with science, that the principal would attend the department meetings. Mr. Thomas said that the administrators gave teacher the freedom to do whatever they wanted, but that they were not directly involved. The other teachers reported that there was no support from administrators, and in some cases, like Mr. Sanchez, said that the administrators at their schools gave science the least priority. In both middle and high schools, it seemed that administrators who were science teachers
prior to their administrative positions showed interest and support for science, for example, the schools where Ms. Coleman and Ms. Armando taught. In general, high school teachers were on their own. Even the six teachers who came from the same school indicated that they did not work coherently as a team in their own department. For example, it appeared that the high school teachers did not have coherent curricula, either. Even though they sat together to create common plans for how to teach the curricula they had, not all voices were valued, and Mr. Nash constructed his own curricula.

Motivation

Middle school teachers did not mention much about motivation; it appeared that everything they did with their students was motivating to the students. Ms. Armando mentioned that her students would ask when the next field trip would be and where they would go, so that they could get prepared. The high school teachers, for the most part, tried to be flexible with their teaching to offer the lessons their students liked most. For them, their teaching required some negotiations with students if they really expected students to participate, and that was also the case with me. For example, if I had a four-day week, where student would not attend on a Friday, I had to come up with negotiations, like “If you come, work diligently from Monday through Wednesday, I will give you Thursday to do anything you want so long as you do not break any school rules.” Without these negotiations a teacher could easily lose high school students. Some of these students did their class work as if they were doing you (the teacher) a favor. It was never about their future that you were trying to create a passage for.

Every teacher used different method based on the students in their classes. Mr. Nash and Ms. Coleman used some motivational talks to encourage students to learn in
their classes. Not all students would listen to long talks like Mr. Nash’s, but that is why it is very important for teachers to know their students and develop a relationship with them. Ms. Coleman taught her students about African American scientists and inventors, both men and women, in order to dispel the myth that black people do not do science as her students had told her. She incorporated sports into her physics classes in order to motivate her students, since sports was something they were familiar with. Mr. Johnson used an interest inventory at the beginning of the year to collect items he could use later in his teaching for motivation. Mr. Zubek covered twice as many units than the other teachers to avoid spending too much time on any particular unit, lest he would be considered *boring!* Or his lessons would *suck*!

Teaching science to high school students requires an element of art, not just spitting out concepts. Mr. Sanchez said that he was a *comedian* in his classrooms. He believed that his first task was to get the students excited to be in his classroom, and then capture their attention at the moment when he knew they would be ready to listen. He said, *teenagers are very selfish people. They want to know that you, their teacher, care about them as individuals….Teenagers are all about me! Me!* He said that if a teenage walks into the classroom and says, *did you miss me?* At that moment you might not recall that they were not in class the day before, but you have to say, *yes. Where were you yesterday?*

**Unpredicted Data**

Middle school teachers, in both their responses to the surveys and interviews, did not hesitate to answer the question about equity in their classrooms but high school teachers were hesitant to answer the question. Some did not answer the question in the
survey and said that they had not understood it. During the interviews I explained what I meant about equity, but they did not seem to like answering the question, *I treat all my students fairly*. During the interviews, all middle school teachers were very excited to speak and wanted to talk about how the students liked science, and how they themselves enjoyed teaching. High school teachers, for the most part, were frustrated, and some showed concern about what was happening with their students. I understood their feelings. It has been very frustrating when I have tried all I could to teach and to motivate my students and then toward the end of the school year some of them wouldn’t show up to class.

Where there was tracking in high school, teachers in the study who taught high performing tracks and then later on taught low performing tracks expressed their frustration when they believed the low performance originated with the students’ experiences with previous teachers. Mr. Nash said his regular track environmental science class students were not motivated and did not perform to his expectations. He thought that the reason was that those students had had a bad experience with their teachers prior to meeting him. This was expressed by Mr. Thomas, too. In general, teachers whose students performed well credited it to their teaching style. Mr. Lazzaro said, *once students found out that they were not going to just read and do worksheets, their interest increased*. Dr. Fierro said, *I have always found that students are interested in science, especially if a teacher teaches to her or his passion, and I think my own passion rubbed off on most of them during those years. But I was incredibly blessed to have such gifted students. By gifted, I mean students who trusted me enough to suspend any concerns that each of them could to be the best learner they could be.*
I have taught at three inner city high schools, and my experience has been the same as what these other teachers described. Teachers who teach higher tracks tend to be sheltered from the realities of inner city classrooms. The students might not necessarily be super smart in an honors or AP class, but they tend to be able to handle the demands of high school. They are prepared and they attend more regularly than students in the lower tracks, and this might lead a teacher to take the whole credit and forget that before these students got to their classes, other teachers before them had made contributions to who these high performing students are.

Another unpredicted datum might be that students are not well informed as to what people do with science. According to the teachers in my study, students who mentioned that they would probably seek careers in science suggested going into medical fields like becoming a doctor or a nurse. It is possible that students think science is limited to working in medical fields and in a lab for life doing some trial and error experiments. This finding is supported by the research done by Archer, Dewitt, and Osborne (2015). This is a gap that we, teachers, can easily close. We certainly can tell students about the wide variety of possibilities for what they can do with science and how many careers are out there that fall under the science umbrella.

Conclusion

This chapter has shown how data were collected using surveys and interviews. The interviews’ data were used to triangulate the surveys’ data. The questions that were used for the surveys were the same ones used for the interviews, where clarifications, expansions, and explanations were extracted. Data were presented in categories that were based on participants’ demographics, education level, experience, and how they got
interested in science, the locations of the schools where they taught, the demographics of the schools, and other pertinent information. Then the participants explained about their teaching, what they taught, who they taught, how the students liked or disliked what was taught, and why they liked or disliked it. The last category was how the participants viewed their students in general, whether they thought the students had an interest in science or not and how they came to that judgement, and how they motivated their students to cultivate interest in science. Then differences in participants’ information based on middle and high school were explained, and main themes for all the participants were discussed.

The next chapter will provide an in-depth discussion in interpretation and synthesis of the findings. It will examine whether the literature corresponds with or contradicts the findings and/or if a second layer of interpretation would be needed. The chapter will conclude by stating the study’s limitations, recommendations and finally epilogue.
CHAPTER FIVE
DATA INTERPRETATIONS AND SYNTHESIS

Introduction

This chapter will interpret and synthesize the findings, compare these findings to my own professional experience and examine whether they correspond with the literature. Issues of trustworthiness will be incorporated throughout the discussion, and data that was not anticipated will be interpreted. The discussion will use themes that resulted from participants’ data in light of my experience and the literature. These are: teachers’ interest in science, students’ interest in science, STEM/STEAM efficacy, administrator and parental support, tracking, motivating students, girls compared to boys, the increase/decrease of science interest with age, equity, and evolution. This discussion will be based on Tables 5.1 to 5.6, which summarize the entire data set from all the participants, from where the themes arose. Finally, the chapter will state the study’s limitations, improvements, recommendations, and offer an epilogue. In this discussion the phrase participants’ students will refer to what participants reported about their students, and my own students will refer to my experience from the students I teach.
<table>
<thead>
<tr>
<th>Participant</th>
<th>Profile</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nortek Nash</td>
<td>• 40 years old; Caucasian man</td>
</tr>
<tr>
<td></td>
<td>• 14 years teaching experience; holds a master’s degree</td>
</tr>
<tr>
<td>Samantha Graeme</td>
<td>• 34 years old; Caucasian woman</td>
</tr>
<tr>
<td></td>
<td>• 8 years teaching experience; holds a master’s degree</td>
</tr>
<tr>
<td>Brienne Williams</td>
<td>• 38 years old; Caucasian woman</td>
</tr>
<tr>
<td></td>
<td>• 8 years teaching experience; holds a master’s degree</td>
</tr>
<tr>
<td>Miriam Dowdy</td>
<td>• Over 60 years old; Caucasian woman</td>
</tr>
<tr>
<td></td>
<td>• 26 years teaching experience; holds a master’s degree</td>
</tr>
<tr>
<td>Henryk Zubek</td>
<td>• Over 60 years old; Caucasian man</td>
</tr>
<tr>
<td></td>
<td>• 28 years teaching experience, 24 science and 4 math; holds a master’s degree</td>
</tr>
<tr>
<td>Drew Johnson</td>
<td>• 55 years old; Asian American man</td>
</tr>
<tr>
<td></td>
<td>• 31 years teaching experience; holds a master’s degree</td>
</tr>
<tr>
<td>Jose Sanchez</td>
<td>• 37 years old; Hispanic man</td>
</tr>
<tr>
<td></td>
<td>• 13 years teaching experience; holds a master’s degree</td>
</tr>
<tr>
<td>Meesha Coleman</td>
<td>• Over 60 years old; African American woman</td>
</tr>
<tr>
<td></td>
<td>• 4 years of teaching special education in science department; a Juris Doctor</td>
</tr>
<tr>
<td>Paul Thomas</td>
<td>• 24 years old; Caucasian man</td>
</tr>
<tr>
<td></td>
<td>• 1.5 years teaching experience; holds a bachelor’s degree in Chemistry</td>
</tr>
<tr>
<td>Estella Armando</td>
<td>• 36 years old; Hispanic American woman</td>
</tr>
<tr>
<td></td>
<td>• 11 years teaching experience, 9 in science; holds a master’s degree</td>
</tr>
<tr>
<td>Louis Lazzaro</td>
<td>• 43 years old; Italian American man</td>
</tr>
<tr>
<td></td>
<td>• 20 years teaching experience; holds a master’s degree</td>
</tr>
<tr>
<td>Dominika Dombrowski</td>
<td>• 25 years old; Caucasian woman</td>
</tr>
<tr>
<td></td>
<td>• 2 years teaching experience; holds a bachelor’s degree</td>
</tr>
<tr>
<td>Dr. Enzo Fierro</td>
<td>• Over 60 years old; Italian American man</td>
</tr>
<tr>
<td></td>
<td>• 39 years teaching experience; holds a doctoral degree (EdD)</td>
</tr>
</tbody>
</table>
Table 5.2
*Personal Attitudes to Science and Why Science Is Important*

<table>
<thead>
<tr>
<th>Participant Name</th>
<th>Participant’s Responses (Direct quotations are in italics.)</th>
</tr>
</thead>
</table>
| Nortek Nash      | • Got interested in science on his own. In high school his science teacher was his role model.  
                  | • Science is important for everyone because it is part of life.  
                  | • Society must be vigilant over safety, environment, products, food, medicine, these require knowledge of science. |
| Samantha Graeme  | • I’ve been a science geek as long as I can remember.  
                  | • Science help students practice critical thinking and gain the understanding of the world around them. |
| Miriam Dowdy     | • Grew up on a farm and was always interested in science.  
                  | • Science help everyone to understand the world around them. |
| Brienne Williams | • Grew up in nature. Grandmother was a college science instructor. She was a role model for me.  
                  | • Make informed decision especially on controversial issues like global warming, GMOs, fracking, energy conservation, health and medical issues. People need the general knowledge of science to be involved in these. |
| Henryk Zubek     | • High school teachers were my role models for science, and my low command of English language made science more appealing.  
                  | • Science gives a better understanding of the laws of nature and teaches students how to think analytically. |
| Drew Johnson     | • I have always been interested in science since I was a child, I love living things.  
                  | • Studied aquatic biology, and took teaching to pay for graduate school, I liked teaching so I stuck with it.  
<pre><code>              | • Science teaches logic. |
</code></pre>
<table>
<thead>
<tr>
<th>Name</th>
<th>Personal Attitudes to Science and Why Science Is Important (cont.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jose Sanchez</td>
<td>• Interested in science since childhood. Watched many nature shows on TV. Mother a role model, was a science teacher.</td>
</tr>
<tr>
<td></td>
<td>• Science is important, it teaches students how to think critically and systematically.</td>
</tr>
<tr>
<td>Meesha Coleman</td>
<td>• As a special education teacher I work with a science teachers, I got interested by observing these co-teachers.</td>
</tr>
<tr>
<td></td>
<td>• Science is important to me because it answers questions about the world in which we live.</td>
</tr>
<tr>
<td>Paul Thomas</td>
<td>• I always felt connected to science and the best avenue for me to pursue that was through teaching. As a child I practiced a lot of my science interest in my backyard.</td>
</tr>
<tr>
<td></td>
<td>• Science is a cog to society…a link between subjects.</td>
</tr>
<tr>
<td>Estella Armando</td>
<td>• I hated science. I started as a history teacher. I was asked to pilot a science curriculum(FOSS) by my principal</td>
</tr>
<tr>
<td></td>
<td>• I fell in love with science after seeing how excited the students were. I got an endorsement in science and has been a science teacher ever since. Science is important because it is all around us.</td>
</tr>
<tr>
<td></td>
<td>• I learned science the ‘old school’ text book way- that is why I hated it, but now I love science.</td>
</tr>
<tr>
<td>Louis Lazzaro</td>
<td>• I have been interested in science since childhood. I enjoyed science fiction and mystery novels. Science was a natural extension of all of these activities that I enjoyed.</td>
</tr>
<tr>
<td></td>
<td>• Science seeks to explain the world around us.</td>
</tr>
<tr>
<td>Dominika Dombrowski</td>
<td>• I was always interested in science. I wanted to be a vet because I always liked animals but decided to be a teacher because I liked kids more.</td>
</tr>
<tr>
<td></td>
<td>• Science is important because it is a vehicle to know the world around us and why things happen the way they do.</td>
</tr>
<tr>
<td>Dr. Enzo Fierro</td>
<td>• I was interested in science from a tender age my main interest was chemistry. My role models were my grandfather and Linus Pauling, the Nobel Prize Winner for chemistry in 1954, after I read his acceptance speech.</td>
</tr>
<tr>
<td>Participant’s Name</td>
<td>Participant’s Responses (Direct quotations are in italics.)</td>
</tr>
<tr>
<td>-----------------------------</td>
<td>--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Nortek Nash</td>
<td>• Large inner city high school, in a large city in Midwest U.S. School is a magnet performing art, IB, business, drafting.</td>
</tr>
<tr>
<td></td>
<td>• Total enrollment 3,043 (2015–16); capacity is 4,000.</td>
</tr>
<tr>
<td></td>
<td>• 81.5% Hispanic; 12.6% African Americans; 2.9% Asian; 2.4% White; 0.6% other</td>
</tr>
<tr>
<td></td>
<td>• 92.1% low income, 9.8% diverse learners, 9.5% limited English, 12.4% mobility</td>
</tr>
<tr>
<td></td>
<td>• Average graduation rate 70%</td>
</tr>
<tr>
<td></td>
<td>• Taught physical science to mostly grades 11 and 12.</td>
</tr>
<tr>
<td></td>
<td>• Not much support from administrators, but not too much interference either. Not much support from parents and community.</td>
</tr>
<tr>
<td>Samantha Graeme (Teaches in the same school with Mr. Nash)</td>
<td>• Taught grades 10–12 in physical science, all the tracks from regular to honors and AP</td>
</tr>
<tr>
<td></td>
<td>• Sponsors science clubs and field trips.</td>
</tr>
<tr>
<td></td>
<td>• In her AP environmental classes, she taught a little bit of evolution.</td>
</tr>
<tr>
<td></td>
<td>• Administrators did not show any interest in science, parents and community were not supportive of the school.</td>
</tr>
<tr>
<td>Miriam Dowdy (Teaches in the same school with Mr. Nash)</td>
<td>• Taught all grades: life science and physical science.</td>
</tr>
<tr>
<td></td>
<td>• Did not support science fairs, field trips, or science clubs.</td>
</tr>
<tr>
<td></td>
<td>• Did not know if administrators supported science or not.</td>
</tr>
<tr>
<td></td>
<td>• Parents did not get involved with school matters.</td>
</tr>
<tr>
<td>Brienne Williams (Same school as Mr. Nash)</td>
<td>• Taught MYP biology and honors forensics. Ran science fairs, garden club, and limited field trips. The only aspect of support from administrators has been science fairs.</td>
</tr>
<tr>
<td></td>
<td>• Parents and community might not have time to support school. Parents are recent immigrants.</td>
</tr>
<tr>
<td>Henryk Zubek (same school with Mr. Nash)</td>
<td>• Taught physical science to all regular levels; co-taught with special education teachers.</td>
</tr>
<tr>
<td></td>
<td>• I suspect the administrators support science, but I’m not sure how they manifest it in ways different from other subjects.</td>
</tr>
<tr>
<td></td>
<td>• Parents are a no-show at school on regular basis unless it is something very serious.</td>
</tr>
</tbody>
</table>
### Table 5.3

**School Information: Science Support from School Administrators, Parents, and Community (cont.)**

<table>
<thead>
<tr>
<th>Teacher</th>
<th>School Information</th>
</tr>
</thead>
</table>
| **Drew Johnson**<br>(same school with Mr. Nash) | - *School administrators do not support science more than they support other subjects, it seem; they emphasize that students pass their classes.*
- *I don’t know if parents support science, but I guess they do. Their presence in school is limited.*
- He taught all grades, regular tracks, life and physical sciences.
- He did not sponsor science clubs, science trips, or science fairs. |
| **Jose Sanchez** | - He taught at an inner city high school, in a large city in Midwest U.S.
- The school capacity is 3,000 students, but enrollment was about 1,050 in 2015–16 school year.
- 93.1% of students came from low income families and 19.4% of students were diverse learners.
- 25.5% limited-English learners and 24.2% mobility rate. Student population was as follows: 73% Hispanics; 12.6% African Americans; 7.8% Asians; 5.1% Caucasians, and 1.5% Others.
- Graduation rate: 77% in four years, 79% in five years. (cont.)
- *Administrators did not support science, not at all. In fact they use science rooms for other subjects. Parents did not support school either.* |
| **Meesha Coleman** | - She taught a small high school, an inner city school in a large city in Midwest U.S.
- School student population was 325: 68% African Americans, 20% Hispanics; 8% Caucasians; 2% Asians, and 2% two or more races. School SES: 99% free lunch.
- *Administrators had background in science and were very supportive, attending science department meetings, and planning. Pay for science teachers’ PDs away from the building.*
- Parents were not supportive but transparent as to why they could not. (Those she had spoken with had told her that they could not help their children academically because they did not know how.) |
| **Paul Thomas** | - He taught at an inner city high school in a large city in Midwest U.S.
- 850 students: 85% Hispanic and 15% African Americans. Free lunch 96%.
- *Administrators support…yes and no. …give us free reign to teach what we want…but aren’t engaged in the practice. Parents first or second generation immigrants, give no support.*
- *Community gave support through an organization called Enlace.* |
Table 5.3  
School Information: Science Support from School Administrators, Parents, and Community (cont.)

<table>
<thead>
<tr>
<th>Name</th>
<th>1</th>
<th>2</th>
</tr>
</thead>
</table>
| **Estella Armando**   |   | • She taught middle school, grades 7 and 8 in a large city, Midwest U.S.  
                      |   | • 852 students: 99.9% Hispanic (Mexican) and 0.1% African American.  
                      |   | • 100% free lunch. Graduation rate 99%. Students were from low income, immigrant community.  
                      |   | • Parents and community very supportive of school and science in particular.  
                      |   | • Administrators very supportive. The principal was a former science teacher.  |
| **Louis Lazzaro**     |   | • He taught in a middle school, grades 6–8; a dual language school for English and Spanish  
                      |   | • A social justice magnet school in a large city of Midwest U.S.  
                      |   | • 652 Students: 84.5% diverse Hispanics, 10.1% Caucasians, 2.8% two or more races, 1.2% Blacks, 1.1% Asians, and 0.3% Native Americans. 58.7% receive free lunch. Graduation rate at 99%.  
                      |   | • Administrators and parents were very supportive of the school. The school was started by parents.  |
| **Dominika Dombrowski** |   | • Taught an IB middle school, grades 7 and 8, in a large city, Midwest U.S.  
                      |   | • 800 students: 99% African American, 1% Caucasian. 100% free lunch, 100% graduation.  
                      |   | • Parents are not too involved at our school, even when we reach out to them.  
                      |   | • The school administrators’ support: Yes and no. There are extreme behavior problems at my school, so they are usually focused on that, but they support my needs as a science teacher.  |
| **Dr. Enzo Fierro**   |   | • A small suburban middle school. A demonstration school for the university where he now teaches.  
                      |   | • The school was for gifted students of well-to-do families. Families were very supportive.  
                      |   | • The school was located in a suburb of a large city in Midwest U.S.  
                      |   | • The administration was not very supportive of science.  
                      |   | • The school had about 300 students, of diverse races and backgrounds.  
<pre><code>                  |   | • The graduation was 100%.  |
</code></pre>
<table>
<thead>
<tr>
<th>Participant’s Name</th>
<th>Participant’s Responses (Direct quotations are in italics.)</th>
</tr>
</thead>
</table>
| Nortek Nash          | • Planned to examine equity even though he saw himself as a very fair teacher in treating students.  
                        • Also plan to include students’ knowledge, include scientists of color and women in his teaching.  
                        • Students work in small groups, some work individually depending on their needs.  
                        • Students who stay after school for tutoring benefit because they get extra tutoring from him.  
                        • He tries to differentiate according to students’ learning styles and IEPs requirements. |
| Samantha Graeme      | • She used different teaching styles, lecture, note taking, discussion, small group activities, and projects.  
                        • Students seemed not to like any work that would require memorization or an effort from their part.                                                                                       |
| Miriam Dowdy         | • *Most students come to school to socialize.*  
                        • Students complain that they are given too much work, they ask for extra credit work towards the end of the quarter or semester.  
                        • It is very hard to engage students in the analytical aspect of science.  
                        • STEM/STEAM are very important particularly for future careers, but students need to start these earlier before high school.                                                       |
| Brienne Williams     | • Any teaching that did not require memorization, group activities, and labs were preferred.  
                        • *Students cannot visualize what they cannot see.*  
                        • Sometimes students resist to learn certain units because of the way they were put together, for example, *the population unit was too long and drawn out.* She thought it would need some tweaking.  
                        • Science vocabulary was also a reason students lost interest, there were a lot of words to learn and remember.  
                        • STEM/STEAM was very important to her and her students because, *it is the future.*                                           |
Table 5.4  
*Teaching Styles, Styles Preferred by Students, and Equity (cont.)*

<table>
<thead>
<tr>
<th>Henryk Zubek</th>
</tr>
</thead>
<tbody>
<tr>
<td>• He taught physical science exclusively. <em>I taught math before science and I start the year by teaching some math because I am convinced you can’t be a good scientist w/o being a good mathematician.</em></td>
</tr>
<tr>
<td>• <em>My teaching method is different from other science teachers, I offer twice as many units because I want to expose students to as many concepts as is possible for an introductory course.</em></td>
</tr>
<tr>
<td>• He thought that introductory courses were for exposure, and that was a way to make students interested.</td>
</tr>
<tr>
<td>• For equity, <em>I don’t pick sides, but insist on mutual respect.</em></td>
</tr>
<tr>
<td>• Tapping into students’ cultures, <em>I would love to do that but I find the endeavor too challenging.</em></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Drew Johnson</th>
</tr>
</thead>
<tbody>
<tr>
<td>• His approach to teaching involved <em>taking inventory of students’ interests at the beginning of the year.</em></td>
</tr>
<tr>
<td>• Students did not like any work that involved math. They did not like any work that involved memorization.</td>
</tr>
<tr>
<td>• STEM/STEAM were important to him and to his students, <em>it may make teaching certain topics that may increase students’ interest in these subjects.</em></td>
</tr>
<tr>
<td>• He utilized cultural aspects of students in teaching, he was also a bilingual teacher.  <em>Cultural events, food, money/currencies, and fashion are what I use in my teaching to connect to cultures.</em></td>
</tr>
<tr>
<td>• Curricula needed some changes in sequencing.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Jose Sanchez</th>
</tr>
</thead>
<tbody>
<tr>
<td>• He thought that STEM education was very important, but to his students, <em>most of them won’t attend or complete college.</em></td>
</tr>
<tr>
<td>• His students did not like any unit with a lot of memorization requirements.</td>
</tr>
<tr>
<td>• Topics that have a lot of activities and group work, especially labs were students’ favorites.</td>
</tr>
<tr>
<td>• His teaching method also involved a lot of telling jokes to his students, <em>I am the director, and they are the actors.</em></td>
</tr>
<tr>
<td>• Curricula was based on NGSS, and he used 5E instructional style, with a great deal of inquiry, <em>which let them (student) explore what they want.</em></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Meesha Coleman</th>
</tr>
</thead>
<tbody>
<tr>
<td>• She taught both life and physical sciences.</td>
</tr>
<tr>
<td>• Students were interested in dissection, so <em>we hold this over their heads that they will dissect at the end of the year if they worked hard and cooperated in class work throughout.</em></td>
</tr>
<tr>
<td>• She had shown her co-teachers the NGSS teaching methods, and this had helped students to try to (cont.)</td>
</tr>
</tbody>
</table>
| Meesha Coleman, cont.       | She brought a video of her teaching using NGSS method (at the workshop) and the majority of her students were participatory.  
|                           | STEM education. She saw the importance of STEM in the value of solving problems and critical thinking skills.  
|                           | *My students need to feel that they have some control over making decisions*  
|                           | In addressing equity, she said that she created lessons with all students’ needs in mind.  
|                           | She also looked at students’ cultural role models and designed her physics lessons to focus on baseball and soccer for Hispanic students, football and basketball for African American students. |
| Paul Thomas               | His students liked discussions especially when he taught astronomy.  
|                           | He used astronomy to teach the scientific methods because, *no one was around when the big bang happened, but scientists have used evidence to claim that it happened.*  
|                           | His students did not like to do anything that required memorization or computations.  
|                           | He saw the importance and value of STEM but his students hardly see the importance nor value of it.  
|                           | His curricula “desperately” needed to be improved.  
|                           | He used open-ended questions, discussions in small groups and whole class, and investigations.  
|                           | He had tried to use cultural knowledge but students were *too disengaged.*  
|                           | He treated all his students fairly. |
| Estella Armando           | She planned a field trip for each unit she taught, students looked forward to these trips.  
|                           | Hands-on activities, group work, labs, were preferred to lectures, worksheets, note taking.  
|                           | Students were particularly excited to visit Washington, D.C. Being in their own rooms; *this room is bigger than my whole house.* They ate out for the first time, they got out of their neighborhood for the first time, and they saw other children and people they had not seen before.  
|                           | STEM education was important because the future careers would be in those areas.  
|                           | She used a lot of cultural knowledge in her teaching, especially since she was of the same culture as her students.  
|                           | *Everyone has a voice in my classroom.* |
Table 5.4  
*Teaching Styles, Styles Preferred by Students, and Equity (cont.)*

| **Louis Lazzaro** | • Students were involved in various field trips and camping.  
• All the students were required to participate in an inquiry project, and some chose a science project. This allowed them to do experiments, so it was popular to choose science.  
• Student liked evolution, especially in the discussion of re-animating the dodo bird and invasive species.  
• In physical science students enjoyed the discussion about the best place to bury nuclear waste.  
• STEM was important for the future problem solving for any situation and environment.  
• Students did not have any subject or topic / unit they did not like.  
• He used students’ cultures in his teaching, and the school being dual language helped with vocabulary. He used cooperative hands-on activities instead of individual work  
• He established norms for his classroom for fairness and justice every voice was to be heard. |
| **Dominika Dombrowski** | • No tracking, had science club the past school year but had only 5 students who attended regularly.  
• A lot of field trips just like the other middle school teachers.  
• Science fair was done as an after school club for extra credit, not very popular.  
• Students enjoyed cell biology, because there were a lot of activities.  
• They also liked the body unit because they were interested in learning about how their bodies work.  
• If a unit had many activities, students liked it, if there were too much reading, less activities, they showed no interest.  
• STEM is very important to my students, *I am happy I taught my students how to use computersystems properly, and I introduced them to engineering.* |
| **Dr. Enzo Fierro** | • He took students to various field trips like other middle school teachers.  
• *He incorporated art to his science teaching*[STEAM].  
• Students were not interested in any work that required memorization.  
• Students were very interested in his own work and accomplishments prior to teaching.  
• Students had an annual science expo where every student celebrated a science idea that intrigued them.  
• He was very supportive of STEM and STEAM.  
• He said that Makerspaces were important to incorporate into a science curriculum.  
• *Textbooks and standardized tests were a kiss of death’ for science.* |
Table 5.5
Interest/Motivation/Attitudes to Science, Future Plans for Science, and Misconceptions about Science

<table>
<thead>
<tr>
<th>Participant’s Name</th>
<th>Participant’s Responses (Direct quotations are in italics.)</th>
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</table>
| Nortek Nash          | • Students are interested in physics more than in other subjects. *Those who choose physics are usually the smart kids who finished the science requirements for graduation. Physics is an elective course. These students want to be engineers.*  
                        • Students are not interested in Earth/space science and/or environmental science. *They had bad experiences with other teachers in lower grades before they met me.*  
                        • Uses motivational talks about performance, money spent on education and students’ ownership of their future.  
                        • Is in charge of modifying curricula.                                                                                                                                                                                                                   |
| Samantha Graeme      | • *I do not encounter many students who show any real initiative in science.*  
                        • *Only a few students indicate they would seek future careers in science. Most show such disinterest in science I don’t bother to ask about students plans for science in college or beyond.*                                                                 |
| Miriam Dowdy         | • *Students were interested in materialistic life styles;* they did not want to hear about college because they knew how to get easy money and did not want to incur the college debt. However, *a few indicated they would become veterinarians, and some would work in health fields.*  
                        • Motivate students by connecting what she taught with students’ culture.  
                        • Dispelled myths, negative stereotypes by discussion and use of scientific evidence.                                                                                                                                                                    |
| Brienne Williams     | • Some students who are interested in science would ask questions about something they heard in the news and things they observed in their daily lives, especially when they studied genetics.  
                        • However, the majority of students were not interested in science. This could be because the school was specialized in different areas, especially performing arts. Some students were interested in business since there was a business school within the school.  
                        • Some of her students had mentioned that they would become physical therapists, nurses, and science teachers.  
                        • Her curricula needed a better vertical alignment. (cont.)                                                                                                                                                                                           |
Table 5.5

*Interest/Motivation/Attitudes to Science, Future Plans for Science, and Misconceptions about Science (cont.)*

| Brienne Williams, cont.                    | • Unfortunately, much of teaching time is taken by BOY/EOY and soon to come NGSS biology assessment.  
|                                          | • She uses video clips and chapter puzzles to motivate students.  
|                                          | • I treat all students fairly.  
|                                          | • Myth: We come from monkeys. *I use Cladograms to dispel this.*  
<table>
<thead>
<tr>
<th></th>
<th>• Myth: Individuals evolve. <em>I reteach to emphasize it is populations, not individuals, that evolve.</em></th>
</tr>
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</table>
| Henryk Zubek                            | • He thought that students were interested to an extent, but the curricula and syllabi were not properly written and organized.  
|                                          | • *You cannot offer in depth teaching for introductory courses*  
|                                          | • Students were not career scholars, they worked long hours after school.  
|                                          | • He asked his students every year about their future plans in science or in anything not just science. *I strongly recommend that they should choose a career (not necessarily one that requires to major in science)*  
|                                          | • Students stated things like, *I want to work in a medical field.*  
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<th></th>
<th>• <em>I don’t come across ethical/religious/cultural issues in physical sciences very often, [and] I try to distinguish between theory and fact—that is, theory is right until a better one comes along.</em></th>
</tr>
</thead>
</table>
| Drew Johnson                            | • *I believe that students are still interested in science but their learning behavior has changed*  
|                                          | • Instant gratification, *they live in an age where everything that they need is given to them, and ‘now’*  
|                                          | • *They want the answers, “now”. They google answers using their electronics, to get the answers “now”*  
|                                          | • Students like to do labs, and group activities, but they do not want to sit down and write what they did and analyze it.  
|                                          | • He always asked students about their future plans in science.  
|                                          | • Very few mention going to college and pursuing careers in medical fields.  
|                                          | • During evolution, he taught his students to approach learning with open minds. *I tell them that just because you disagree with something it does not make it wrong, science is based on hard evidence, and religion is based on beliefs.* |
### Table 5.5
*Interest/Motivation/Attitudes to Science, Future Plans for Science, and Misconceptions about Science (cont.)*

| Jose Sanchez                                                                 | Being interested in some aspects of science but not in school or learning as a whole. *Students come to school to socialize not to learn, my dad (a retired high school counselor) had told me this.*  
|                                                                             | He talks to his students about future plans for science, and sometimes general future plans.  
|                                                                             | I have 2 students currently in college studying biochemistry like I did, one in Biology. I also have one students who graduated with an engineering degree. I was their “role model” from the Kung Fu club, I did not have them in my science classes.  
|                                                                             | His few other students have mentioned going to medicine, also the one who is in college for biochemistry plans to be a physician.  
|                                                                             | Misconceptions in science: I tell students that I am not here to change their beliefs. Only to teach a theory. The better they know the theory the more informed their arguments can be.  

| Meesha Coleman                                                            | Students were not interested in science, and some were not passing the classes because of poor attendance and then they were surprised that they had to re-take the classes to graduate.  
|                                                                             | In physics, students showed a little interest because they could move around to do some activities.  
|                                                                             | In chemistry, students are shocked even disappointed that they are not participating in labs that involve chemicals, more importantly they want to see something explode.  
|                                                                             | In motivating students, particularly since students said that what they were learning would have no use in their future lives, and that Black people did not do science, she gave two talks: One for those planning to go to college, and what information they would need. The second was for those who had asked her how they could get stable jobs after high school. She told them that, high school will give you a minimum wage job. She still encouraged them to go to a two year college, or find a trade and go to a training for it. She gave students resources for this.  
|                                                                             | As for Black people not doing science, she proved her students wrong by giving examples of Blacks who were scientists in the past and currently.  

| Paul Thomas                                                               | He said that, by the time students get to me they’ve lost a lot of desire to learn science this was because they would have been with other teachers who used old teaching methods they have used for years.  
|                                                                             | He talked to his students about their future but not in science.  
|                                                                             | A few of his students would go to college, and some might major in science but he said those are very few.  

### Table 5.5

*Interest/Motivation/Attitudes to Science, Future Plans for Science, and Misconceptions about Science (cont.)*

| Estella Armando | • Her students and all the students in the school were very interested in science.  
|                | • She motivated students to follow a science path.  
|                | • She had students who have mentioned they would seek medical careers as astrophysicists and engineers when they grew up.  
|                | • She used a curriculum called Science Education for Public Understanding (SEPUP) and she liked it. So did her students.  
|                | • She used talk moves, whole group discussions, and driving question board to dismiss any science misconceptions.  
|                | • Families of her school community were very religious, so when she taught evolution, she told the kids, *I am teaching you another science unit, and I am not teaching about your faith or anything that your family has taught you about your religion.*  
|                | • When she took the students to Washington, DC, the parents sent figurines of angels and saints for the protection of the children and herself. She accepted them to support the parents’ beliefs. |
| Louis Lazzaro  | • Students were interested in science: *They are more likely to see the connections between scientific topics and their lives.*  
|                | • For future science plans: *When I see a genuine interest in science I will often talk about careers that relate to that student’s interest.*  
|                | • Future plans for science: *Few students will talk about college or beyond college, as they are focused on high school first.*  
|                | • Curriculum: I enjoyed the curriculum as it was—the curriculum that I recommended for school.  
|                | • He said that more materials were needed in order to teach science to all students every day.  
|                | • He said that he was the *science guy* for his school and *his department supported his efforts*. He was sure he would get all the materials they needed for the coming school year.  
|                | • He could not recall any controversial theories mentioned in his classroom; even with evolution the students did not question anything. |
| Dominika Dombrowski | • Students were interested in science, especially labs, but the behavioral problems inhibited the frequency of labs.  
• The majority of her students said they wanted to be doctors.  
• She too liked her curriculum, which was SEPUP, like the other middle school teachers.  
• To motivate students, she used world cultures and ethnicities units based on the IB program, especially during the genetics unit.  
• Use of computers was also part of her motivation and engaging her students. Students like computers.  
• During the evolution unit students expressed misconceptions about dinosaurs and human evolution, and some wanted to know what was involved in the birth of twins or more babies than a single pregnancy.  
• The evolution unit caused many problems in her classroom, kids were calling each other names—*You look more like a monkey than I do*—things of that nature. She tried her best to address these issues. She said she covered the multiple births question as part of body systems study, and she used the Monkey Trials movie to discuss more about evolution.  
• At the end of the unit she took the kids to the museum so that they could see the evolution timeline for dinosaurs and other organisms up to humans. |
| Dr. Enzo Fierro | • His students were interested in science, and he thought that his own passion *rubbed off on most of them during those years of teaching grades four through eight.*  
• He was the designer of the curriculum.  
• He taught the students for many years and was very familiar with their families, so *their cultures were part of [his] teaching.*  
• He let the students know that it was their responsibility to learn.  
• He said that the students had been with him for a number of years and *they knew they could always count on [him] to be fair.*  
• He did a set of activities around the nature of science to address myths or misconceptions. Above all, he taught students to understand this: *My beliefs are not what I teach. I teach science which is independent of anyone’s beliefs.*  
• He had had a lot of success with students who went on to pursue great careers, science among them. |
Table 5.6

*Science Interest by Age and Gender*

<table>
<thead>
<tr>
<th>Participant’s Name</th>
<th>Participant’s Responses (Direct quotations are in italics.)</th>
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<tbody>
<tr>
<td>Nortek Nash</td>
<td>• He did not observe either increase or decrease in science interest by age or gender.</td>
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<tr>
<td>Samantha Graeme</td>
<td>• No evidence observed, but she said she had more girls register for AP classes than boys, though they did not work harder than boys. This past school year the AP students’ performance was very low; I suspect they registered in order to increase their GPAs.</td>
</tr>
</tbody>
</table>
| Miriam Dowdy        | • Had not noticed any difference between boys and girls.  
                      • As for age, their difference in level of maturity may increase as students get older, but not interest in science. |
| Brienne Williams    | • Had not observed any difference by gender.  
                      • Maybe interest decreases by age—she does not see many upperclassmen taking science electives. |
| Henryk Zubek        | • *I think that girls are less rebellious toward authority; hence they will take to instructions better.*  
                      • *I am still able to “bully” them, but once boys refuse to do something, that is it. They are not afraid of my authority. In the end, it is the girls who are doing the work and passing classes.*  
                      • *Once in a while I get a very smart boy who seems to know everything, but I mean once in a long while.*  
                      • *I have warned the boys that the future of the world belongs to women.*  
                      • About interest increasing or decreasing by age: *Sometimes it goes both ways.* |
| Drew Johnson        | • He had not noticed any difference in interest by gender.  
                      • However, he noticed that *interest in science decreased with age. As students evade demanding work as they move up in grade level, things get more difficult, and they become frustrated and give up.* |
| Jose Sanchez        | • He had not noticed any difference in interest by gender.  
                      • He thought there could be *an increase in interest with age, maybe due to maturity level, but that would be true for those already interested in science, but decreases with age for those not interested in science.* |
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<tr>
<th>Table 5.6</th>
<th>Science Interest by Age and Gender (cont.)</th>
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<tbody>
<tr>
<td></td>
<td>Meesha Coleman</td>
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</table>
|            | • She said that she was surprised how boys were not worried about getting something wrong; they always tried to relate the lessons to real life situations. Even the low performers did not care if they got it wrong. However, for girls, unless they were sure of what they would say, they said nothing.  
  • She felt that it was hard to say—just because boys were willing to speak out did not mean that they were able to write what had been taught to them compared to girls; many times girls got it right.  
  • She appreciated the boys for at least speaking their minds.  
  • She did not think that interest increased with age. Freshmen come to high school saying that they knew everything I was teaching them, but they could not explain what or how they knew. |
|            | Paul Thomas                              |
|            | • Has not noticed gender differences.    |
|            | • She observed that interest decreased with age. Seniors did not care as long as they were passing. |
|            | Estella Armando                          |
|            | • More girls than boys were interested in science. They had taken initiatives to run science clubs. They attended weekend science workshops and summer camps.  
  • She had not noticed any increase or decrease by age. |
|            | Louis Lazzaro                            |
|            | • Female students still felt that they could not do science. It was less likely to see them participate in class discussions for fear of getting it wrong. Ironically, the girls tend to be able to explain their thinking better than many of the male students.  
  • As for age, once students see that they are not going to just read and do worksheets, the interest level rises throughout…I would say the interest increases with age. |
|            | Dominika Dombrowski                      |
|            | • Boys became too excited during labs and destroyed everything for everybody. Girls could control their excitement and do labs.  
  • And, interest decreased with age. Eighth graders fought too much and their preparation for graduation took too much of their time and imagination. |
|            | Dr. Enzo Fierro                          |
|            | • I told my students that science is gender neutral.  
  • In his teaching he observed that interest increased with age. |
Research Findings

Data from my study showed that participants’ students in middle schools were interested or very interested in science compared to participants’ students in high schools. This data supported my personal experience with my own high school students, who have very little interested in science. The data from my study coupled with my own students are supported by Ebenezer & Zoller (1993), Murphy & Begg (2005), Osborne (2000 & 2008), Simpson & Oliver (1990), Sorge, (2007), and Tai, Maltese, & Fan, (2006) who found in their research that interest in science decline as students move from elementary schools through middle school and by high school they have made their minds about whether or not they will voluntarily continue to study science.

How Useful Was the Research Framework?

I intended to study a sample composed of students using the CRT & LatCrit conceptual frameworks. This was not possible, however, because the Institutional Research Review Board (IRRB) of my school district board of education would not give me permission to involve students. Had I used students I could have been able to judge the strength and validity of the framework in relation to the study better than I have been. Participating high school teachers, were hesitant to explain how they made sure that they treated their students equitably, and how they made sure that students treated each other fairly and equitably. Middle school teachers were forthcoming in the answers they provided in the surveys and also during interviews.

The reason I had chosen this conceptual framework was to see if students were going to tell me why they were not particularly interested in science. Teaching evolution to my own high school students informed me that students harbored some painful
feelings with regard to aspects of the subject. This was not because of their religious beliefs: they were more concerned with the fact that apes are the closest relatives of humans. They felt that this juxtaposition was not applied to all humans, but only to Black people. That made me aware that the students perceived attitudes about race and evolution in their everyday lives that I recognized as a residue of nineteenth-century ideologies about race influenced by eugenics theories.

My own high school students were actually upset that I would teach them evolution—given the fact that I am one of them. As an African woman, shouldn’t I know not to bring such hurtful stuff to the classroom? The fact that students might take biology in their freshmen year in high school this might be a turn-off to science if they are concerned about or have been exposed to these racist ideologies. I also know it is near to impossible for a Black or Hispanic child to grow up in America up to high school and be ignorant of such racist ideologies. This has made me wonder whether teaching evolution was appropriate for students at levels before college; why would they want to learn something that would cause them distress.

On the last day of the workshop where I got the participants the topic of discussion was evolution. One teacher in the group said that she taught evolution using the theory of evolution by Charles Darwin and also creationism. The rest of the teachers were surprised and questioned her, and her explanation was that she wanted to give her students different views on evolution. Two teachers who taught in grade schools with predominantly African American students—kindergarten through fifth grade—reported that their students say that We are monkeys, even though these teachers do not teach evolution to these young kids. It is something the kids say from time to time or when they
fight with each other. This discussion was not necessarily smooth among the teachers in
the workshop. There were some tensions among the teachers because there was no clear
standard for teaching evolution in the schools. Some teachers explained that they taught
evolution but avoided teaching about the evolution of primates. Some teachers said that
evolution was a topic of choice and it was up to individual teachers whether or not they
wanted to teach it and how far they would go with it. This clearly showed that there was
no agreed-upon curriculum for evolution and that teachers in the same district or same
school have liberty with this subject. Although the workshop sessions up to that point had
been productive and collegial, this last session ended the week at a high level of tension.

Judging from the findings of my study Critical Race Theory and Latino/Latina
Critical Theory (CRT-LatCrit) frameworks have made me realize that when teaching
science to minority students I have to remember that they come from a different *habitus*
with less *cultural capital* (Bourdieu, 1986, in Osborne, 2013) compared to what the
school culture and curricula in particular entail. I am using Bourdieu’s concept of *habitus*
in this situation to demarcate the nature of the schools which are set with middle-class
mores and students who come from lower-class families. Science itself, like biology, uses
a lot of foreign vocabulary, much of which is completely new to these students. One of
the teachers in my sample suggested that this could be among the reasons students are
turned off science. Yet biology is a required course in all the participants’ schools for
high school graduation.

What I gathered from the rest of the teachers in my study was that they were
working very hard to teach their students to acclimate to science and succeed in school.
Basu. (2010), Basu, Barton, Clairmont, and Locke (2009), Basu and Barton (2009), and
Calabrese Barton (1997) advocated for science teachers to use democratic methods when teaching minority students whose voices has been silenced, who come from marginalized groups. These researchers thought that teaching science to minority students should be considered a civil rights issue. As teachers we cannot accept students’ mindsets when they say that science is not for them or that there is nothing we teach them that would impact their future lives. We have to contradict these ideas and use antiracist science teaching techniques (Gill & Levidow, 1987). The students of the participants as well as my own students have come to believe that science is for certain groups of people but not the groups they belonged to, and that is not true. Ms. Coleman in my study was able to dispute what her students thought about science by providing them with hard evidence of African American scholars who are scientists. Interestingly, her students had never heard of these scientists.

I found the following authors listed in the reference section of this paper especially helpful in describing approaches and methods for teachers of minority students: Cocharan-Smith, Darling-Hammond and her associates, Ladson-Billings, Margolin, McDonald, McIntosh, and Nieto.

**Answers to Study Questions**

It was hard to say whether or not all the questions were answered. The first question was *What robbed students of interest in science as they navigated from grade school through middle school to high school?* Following what research in the field has indicated, students start with a strong interest in science, almost like an inborn quality. They move through grade school without problems, then they come to middle school and the interest starts to be challenged somewhat but not severely. Unfortunately, by the end
of middle school students’ interest in science has drastically suffered regression (Archer, et al., 2010; DeWitt, et al., 2013; Taylor & Graham, 2007). By the time they enter high school their interest is by then at a critical stage. My study has shown that students of the participating teachers had followed similar paths, which was supported by my observation of the students I have taught for over ten years.

However, in this study students in the middle schools were not typical of those reported in the literature. These students were holding strong up to eighth grade. There could have been different factors in play. For example, Ms. Armando’s students were in a neighborhood school within a monoculture community, and she was of the same ethnicity as her students. She could switch languages in her teaching, and that could have been an advantage, as noted in Murnane and Levy (1996) and supported by Hanushek and Rivkin (2004). Ms. Armando’s school was an extension of the community as she described the strong relationship and support among the three: the school, parents and the community. This was a good example of a neighborhood school.

The data revealed what students liked about science and what they did not like. The majority of students from middle school to high school disliked computations and memorization, so any unit or lesson that demanded these two methods were disliked or avoided completely. Students liked to work in small groups doing activities and labs, but they did not like to analyze the activities and labs after they were done. This was true even more so for high school students than for middle school students. There were more field trips to science related venues and activities in middle schools than in high schools. However, the participants did not indicate that the field trips increased their students’
interest in science but field trips made their students excited to get out and see places. For the middle school students, especially, it was something they looked forward to doing.

This question of waning interest was answered by looking at different teaching styles the participating teachers used. All the teachers knew what students liked and disliked. However, it was hard for high school teachers to completely avoid what students did not like, since some concepts are difficult to teach without using math or without demanding some serious study and a little memorization from the students. These findings mirrored what I had experienced with my own students. I created some mnemonic devices for my students to use, similarly to a participant, Mr. Johnson, and encouraged my students to create their own devices for some concepts that required minimal memorization but the majority of my students did not choose to use such methods. It was not that they could not do it, but they would not do it.

It is hard to know what robs students of their interest in science. According to literature, it is a myriad of factors (Beatty, 2013; Lareau, 2003; Saporito & Sohoni, 2007), and some of these factors are better spoken about by students themselves (see, Kidman, 2008). At least there was a strong agreement among all the study participants that when the students, the parents, and the school worked together—which happened in grades below high school—students had a strong positive attitude to science and their interest was supported by their achievements (Hill & Craft, 2003; Rice, et al. 2013; Shumow & Miller, 2001). And, the opposite was truly the case when the school, parents and community were not a cohesive unit, as the high school teacher participants reported. Minimal parental support of schools corresponded with students’ loss of interest in school; this is supported by Hoover-Dempsey, et al. (2005).
The second question was stated as follows: Have students read or heard from families, teachers, or peers anything involving past theories about science that could have contributed to their lack of interest in science? As mentioned above in the section about the usefulness of the conceptual framework, I could say that students were very much aware of the past. This came out during units on evolution when students said “We come from monkeys,” and the way students addressed this concept indicated that there were stereotypes, prejudice, and a stigma attached to what they were saying. This was a sensitive issue, and not every teacher would feel comfortable talking about it. The evidence for this was the body language and the hesitation from the teachers during interviews. Middle school teachers handled it better than high school teachers. This question was partially answered, and it is my hope that in the near future I could continue the study, this time with student, to see if the question would be fully answered.

Question three was stated as follows: do students understand the importance of science for themselves and for the society in general? Based on the study’s participating teachers’ explanations, their students understood the importance of STEM and STEAM. The teacher participants also understood the importance of STEM and STEAM as widely projected for the future job market and claimed that they taught their students the importance of these fields for their students’ better future. I then realized that the participants were doing exactly what I had done with my own students, and I concluded that it was not the case that students were ignorant of the importance of science, but that they were simply not interested in pursuing it themselves. Ms. Coleman’s students told her that Black people do not do science. They felt that science was important, but someone else had to do it. My students, Ms. Dowdy’s, and Mr. Sanchez’s expressed
wanting to get a job and earn an income as soon as possible. They believed that if they were to go to college and study science it would take too long before they got a job in that field, despite that we have been telling them that science fields offer stable employment with good benefits. Their attitudes were that science is a lifetime commitment, and therefore they were not interested in it.

This last attitude of not being interested in a lifetime commitment does not necessarily come from a lack of thought about the future but, often, the opposite. Many of my own students have told me that, in view of the violence that surrounds them, they have very low expectations of living into adulthood. Their markers for life achievement are short-term, such as having a baby that will live after them as evidence of their lives—as their legacy. These are quite valid concerns given that these young people have lost family members and friends at very young ages due to rampant city violence.

Seeing this heartwrenching outlook on life in my students was the major factor impelling me to do this research. I urge them to make the effort to do well in school and go to college and go into STEM field careers as a pathway toward upward mobility for themselves and hope for themselves and their family’s future. Education in itself is, of course, one of the best means to socioeconomic betterment. But I think STEM fields are particularly promising for students of color and for young people from lower economic classes because they provide decent-paying, stable jobs. People attempting to move out of life settings such as the ones my students have are in effect their families’ socioeconomic pioneers. The journey is seldom easy for them on practical and emotional levels, and they need work that is stable and dependable over time. It’s true that some people of color are highly visible as achievers in the fields of sports and entertainment. But opportunities in
those are fewer and more dependent on and vulnerable to chance than those in the STEM areas, where current and anticipated expansion can be expected to offer opportunities well into the future for those who prepare themselves for work in them. It is painful for me not to see people of color better represented in these fields, both for their personal benefit and as role models.

Furthermore, as one especially interested in the sciences, I know that good emerging evidence shows that scientific knowledge and practices would benefit from a great deal more diversity among its researchers and practitioners, including people from backgrounds like my students’. What areas are chosen and financed for research, how the research is framed, and how it is interpreted are all unavoidably affected by who the decision makers and interpreters are. For example, recent research initiated by women has revealed that decades of heart research done only on and about men does not tidily apply to women, on whom very little heart research had been done. With the necessary education, people with social and racial backgrounds like my students’ working in the sciences can furnish perspectives whose absence might otherwise make outcomes less accurate or effective.

**Interpreting the Themes in the Findings**

**Teachers’ Interest in Science**

All the teachers except two had been interested in science from childhood or some from later on after they had met role models. The majority became interested on their own; they did not remember anyone having influenced their interest. Theirs was an individual interest which, according to literature, is a strong determinant of academic achievement (Schiefele, Krapp, & Westeler, 1992). They happened to be in an
environment that allowed them to experience nature or to do some activities that led into liking science. Ms. Williams, Mr. Thomas, Ms. Dowdy, and I were good examples. Some teachers had role models who enhanced the interest they already had, which was an advantage. Parents and family members were also mentioned as being role models, like in the case of Ms. Williams—her grandmother—and Mr. Sanchez, his mother. To have intrinsic and extrinsic interests together is considered a firm benefit for academic motivation (Murphy & Alexander, 2000).

The two teachers who were not initially interested in science, Ms. Armando and Ms. Coleman, ended up being very interested after they started teaching it. And Ms. Armando, who had outright hated science, changed her mind to I love science. Her interest was triggered by her students’ excitement in her teaching. Her situational interest has become persistent motivation and learning (see Hidi & Anderson, 1992). These two examples suggested that the students that we now teach, who currently do not like science, might, later on in life, become like Ms. Armando and Ms. Coleman. Overall, all the teachers were highly motivated with their teaching job and wanted so badly to have their students develop positive attitudes to science (see Hidi & Harackiewicz, 2000).

Mr. Sanchez discovered long after the fact that he had served as a role model for some of his students. The after-school kung fu club he led had changed some of his students’ discipline even though he did not know it at the time. They came to tell him later that they had gone to college because of his kung fu club. Role models are very important for students’ interest in learning (Eccles & Harold, 1993; Seymour & Hewitt, 2000). Mr. Nash and Mr. Lazzaro were influenced by their teachers and they strongly
revere their teachers so much so that they believe they could not have been science teachers had it not been for their teacher-role models.

**Students’ Science Interest**

In this study there was a clear demarcation between high school students and middle school students. High school students were not interested in science unless they were in the honors, AP, or IB tracks. But even students in these tracks, who would be expected to show interest, did not always rise to their teachers’ expectations. The results of my study in this area are supported by literature asserting that students’ interest in science decreases with age (Ebenezer & Zoller, 1993; Murphy & Begg, 2005; Osborne, 2000 & 2008; Simpson & Oliver, 1990; Sorge, 2007; Tai, Maltese, & Fan, 2006). One thing that was common across the board was the ways by which students preferred to learn science. They did not want to take notes, listen to long lectures, or participate in lessons that required them to memorize or do math. They liked lessons that were full of activities where they worked in groups and that allowed them to move around, and they liked units that had a lot of lab work. Ms. Dombrowski said that her students would become overexcited on lab days—especially the boys—to the extent that they destroyed lab materials and interfered with the conduct of the lesson activities. They seemed to regard the lab equipment and materials as toys to be played with. Ms. Coleman’s students came in in September wanting to dissect. So did my own students, and the classes of many other biology teachers. She had to hold the anticipation of dissection over their heads to make sure that they would work throughout the year with the hope they would dissect near the end of the year. This trick worked for some time, with my students, but
some students would give up because it was too long to wait and hope to get that chance to do something they wanted.

It appears that we, science teachers, need to look at our curricula and provide lessons aimed at giving students general science skills, instead of focusing on college entrance needs. Millar and Osborne (1998) have suggested that the curricula could focus on scientific literacy, which is necessary for everyone. On the other hand, Schwartz and his colleagues (2009) reported that students who did not get a science subject covered in depth in high school struggled in college compared to their peers who had a subject covered in depth even for one month. Some researchers, however, found that students wanted to be taught science with cutting edge technology. For instance, in biology they are interested in biotechnology (Kidman, 2008; Ornstein, 2006; Trumper, 2006). These new science fronts may require more financial resources than now available for most inner-city middle and high schools, but might be readily available at college level.

Students in middle and high schools need to have explained to them that in preparation for what they desire, they need to learn patience during the period of learning the basics in order to finally get to college where the advanced technology is available. Some universities and other institutions offer summer programs for middle and high school students. This is another avenue for students interested in getting their hands into cutting edge science technology early. Again, this comes back to interest, because a student must show interest and evidence that they have done well in school to get recommendations to such cutting edge technological institutions.

The middle school students in my study were very excited to go on field trips, and their teachers felt that these field trips were a factor that increased their interest in
science, to a lesser extent, since they were eager to get out of their neighborhood. This concept was supported by Uitto, et al. (2006), who found that activities outside of the school improved students’ interest in biology. My personal experience has shown this to be true with my students. Unfortunately it can be very challenging to organize field trips with more than 100 students. The challenges involve time, money, and finding chaperones. One time I, with a couple of chaperones, took a class of about thirty students on a field trip as a reward for their effort and good behavior. Students used their own money to pay for public transportation and for lunch. When I returned with them, they bragged about the trip and their novel experiences to the students in my other classes, to the extent that the other students were angry with me for the entire school year for being left out. From that I learned the hard way that the outcome of such trips outweighed the benefits.

**STEM/STEAM Efficacy**

The study’s survey and interview data did not reveal any lack of understanding of the importance of STEM/STEAM education on the part of students. The teachers had continually explained why it was important for their students to take STEM education seriously. Despite this, the high school students did not plan on pursuing STEM careers (as reflected in Jenkins & Nelson, 2005); they seemed to have already made up their minds. Those few who were striving to go to college expressed their interest in STEM to their teachers. The rest of the students told their teachers that they merely wanted to finish high school and get a job.

According to Tobias’s study (1990) of non-science college majors and students who took science and then switched to other majors in college, these students held some
stereotypes about students who major in science and about science as disciplines. The students in Tobias’s sample participated in the study by auditing science courses. These auditors found out that science created a culture of competition and a culture of competence. The auditors’ observations of the science students were that they were *bored, tired, and scared.* Students who did not choose science felt that majoring in science would not provide them with as well-rounded an education as a liberal arts degrees. They had this opinion because, they said, science does not allow for independent thought—it is all about facts, cut-and-dried, which could not be argued against, so that one could take a science class and even get a good grade but not be able to explain what they had learned. So, non-science majors felt that science is too rigid and passive, does not allow for any type of flexibility to engage them. Some auditors held the stereotype that those who major in science are child prodigies, while others thought that *anyone can do humanities, but not everyone has the discipline to do science.* (p. 78). They also thought that those who concentrated in science had IQs 11 points higher than humanity majors, and only dummies went into English.

Even though Tobias’s study was for college students rather than middle and high school students, much of what these auditors said was similar to what high school students say, according to the teachers who participated in my study. When Ms. Coleman’s students told her that *Black people do not work in scientific fields,* it reinforced what was reported in the literature (e.g., Archer & Francis, 2007). College students in their study asserted that those who majored in science worked very hard, which intimidated those who had thoughts of entering the field, hence made them too scared to even try.
Administrative, Parental, and Community Support

There was a clear difference between the middle schools and the high schools in my study in areas of support for science provided by administrators and parents. All middle school teachers except one reported strong support among the school, the parents, and the community. The middle school teachers also felt that they had strong support from the administrators of the school. Ms. Dombrowski, who had a big problem with students’ behavior, had strong support from the administrators and staff, but did not have support from the parents. This was a teacher who was about to quit only to realize that the students loved her, and that their behavior was caused by complex out of school factors (see Beatty, 2013). Because of that insight and the support she received from the administrators and staff, she decided to stick around. Lack of support for novice teachers has been found to contribute to teacher attrition rate. It was reported that 40% of first year teachers leave the profession within the first five years of teaching in urban high schools (Rinke, 2008).

Most teachers, as reported in the literature, are attracted to highly functioning schools with strong administrators, dedicated colleagues, and soundly teachable children regardless of their socioeconomic status (Jacob, 2007). My study, however, includes an example of a middle school in a low economic area but in which the teacher reported to have had strong support from parents and administration. Rice, et al. (2013) reported how strong social support from parents, teachers, and friends can change students’ attitudes toward perceptions of their ability to do math and science. Other researchers who have found similar results are Dornbusch & Glasgow (1996), Eccles & Harold (1996), and Simpson & Parsons (2008). All of them added that parents with low education and low
income, immigrants, and populations of minority groups were less likely to get involved in school matters. The populations for my study were typical of what these researchers are talking about.

Parents from the groups mentioned above might feel isolated and intimidated due to language and cultural barriers. This alienation would not be experienced by parents who are familiar with the school culture, have high incomes, and high education levels. Such parents tend to be comfortable and effective in working with school officials because of the shared interests and trust in each other that comes with familiarity. This general pattern of parent-school relationship was addressed by Hoover-Dempsey, et al. (2005) and Lareau (2003). High school students in my study who speak English and understand the culture of the school, although their parents do not, exert substantial influence on their parents’ involvement with the school. For example, Ms. Dowdy, one of the participants in my study, explained that even when she tried to get hold of parents by calling them, much of the time it was the students who answered the phones, and they could choose to share or not to share with their parents what the call was about. If, she said, for example, I am calling to report something they don’t want the parents to know, they are the translators, and they won’t give the message to the parents.

In comparing middle school parents to high school parents, Shumow and Miller (2001) reported that middle school parents were more involved with the children and would visit the school to celebrate their children’s success. But if the students were in trouble at school, the parents were more inclined to discipline the child in private at home than to come to the school. The parents’ level of education might be a reason for them not to get involved even if they wanted to. In my study, Ms. Coleman said that some of the
parents told her not to give homework to their children because they did not have enough
education to help them. Hall, Davis, Bolen, and Chia (1999) made similar observations.

**Tracking**

Tracking was practiced only in the high schools in my study, and, based on what
the teacher participants reported, there were differences between students in regular
tracks and those in honors, AP, and IB tracks. Most of the teachers stated that they held
higher expectations for students in these higher-level tracks than for students in the
regular tracks. Ms. Williams, for example, spoke about a class of MYP students whose
attendance was perfect, but who did not say anything in class for the whole first semester.
She said that she had never experienced that before. That could be an area of research—
to find out why such a thing would happen. It could have been anxiety involving the
move from middle school to a large high school, or it could have been a culture shock, or
a combination of many things. Ms. Graeme reported her frustrations with her AP
environmental science class for the 2015–2016 school year. She said that they did not
apply themselves to the level of AP, and she wondered whether their motive to take AP
was simply to improve their GPAs.

Those who have researched the issue of tracking are split, some support tracking,
but cautiously, and others discouraging it. Gamoran, et al. (1995) observed that
participation and discussion in honors tracks were observed more frequently and were of
higher quality compared to regular tracks. They observed open-ended questions in both
tracks, but felt that the honors track benefited more because of the frequency of this type
of questions. Participating teachers in my study had to work hard to convince students to
join honors or other higher tracks. They addressed the fear students have of joining
advanced classes that they perceive to be for high-performing students, which they do not perceive themselves capable of being. They are afraid of failing and feeling shamed by being bumped back to the regular track. In my own experience, Hispanic girls’ strong personal relationships can also hold them back from attempting advanced classes if their close friends are not interested in or capable of higher-level work. Futrell and Gomez (2008) challenged the concept of tracking altogether. Their main complaint was that low tracks consisted mainly of minority, poor, and English learners, and that such arrangements created inequality.

Mr. Zubek, one of the teachers in my study, was concerned that students in regular tracks might be lacking the challenge they could have gotten from peers who were in these high performing tracks. He also felt that the high performers could have been role models for the low performers. While I agree with him, I also know that every situation has to be assessed individually: these are delicate issues. From time to time I have advocated for certain students to leave my regular classes to go to honors or AP classes after I realized that the rest of the students did not appreciate their efforts to learn or want to work fairly with them. If I asked a question and nobody wanted to try to answer, and then I called on someone, I would hear, why don’t you ask her/him [the diligent one]? When things got to that point, it was a prompt for me to arrange for that student to leave and join students who were his or her peers in aptitude, but mostly in attitude. I consider attention to such students’ plight an aspect of equity.

**Girls Compared to Boys**

The middle school teachers in the my study, Ms. Armando and Mr. Lazzaro, reported that the girls in their science classes were still caught up in the idea that science
was for boys, but their conduct and performance belied that notion. Ms. Dombrowski, who taught in a neighborhood school and whose male students were excited to the degree that they destroyed classroom materials, reported that her female students were attentive compared to boys and did much better than boys. Ms. Armando, who was also in a neighborhood school, described her girls as the \textit{go-getter} type. They would stay after school and do extra work, run clubs, apply for funds. Boys, on the other hand, would not give after-school science activities much of their time; instead, they would play sports outside with their friends.

The situation was different for Mr. Lazzaro and Dr. Fierro. Both of their schools are in affluent neighborhoods. They have students who are very high-performing—Mr. Fierro’s kids are gifted, and Mr. Lazzaro’s kids are in a magnet school. Neither reported a difference between boys and girls. This aspect of gender has been well studied, and I have avoided putting too much emphasis on it because my personal teaching has shown girls to be hard workers who performed better than boys.

High school teachers in my study did not see much difference between boys and girls. However, gender studies have shown that middle school to high school students tend to have a stereotype of \textit{a scientist} as a middle class white male, and that traditional perceptions of sex roles interfere with their choosing or not choosing science. The following authors are particularly of interest. Archer, Dewitt, and Osborne (2015); Chambers (1983); and Dunnell & Bakken (1991).

**Does Science Interest Decrease or Increase with Age?**

The majority of the teachers who participated in my study felt that interest decreases with age. The middle school teachers did not see a dramatic decrease until near
the end of the eighth grade, when students’ attention was shifting to preparation for graduation and the move into high school. High school teacher participants, who taught all grade levels, noticed that freshmen came in with a little interest, and then it declined from there on. Those who taught only juniors and seniors had a problem answering the survey question, because they never saw any interest in their students to begin with, so for them an increase or decrease was hard to discern. Similar observations were reported by DeWitt, Archer, and Osborne (2014), who claimed that science ambitions are formed between ages 10 and 14, and Murphy & Begg (2001), who claimed that if interest was lost during primary education it was unlikely to be developed in the secondary years.

**Equity**

One of the questions in my survey was, *how do you resolve biases between teacher/students or among students?* Sources useful in formulating this question were Basu (2010), Basu and Barton (2009), Basu, Barton, Clairmont, and Locke (2009), who addressed issues of equity in their explorations of *democratic pedagogy in science classrooms, teaching science for social justice, and critical science agency.* They particularly expressed how important it is to understand power and what they called *positionality* in order to learn science. What I was looking for was discussion of any classroom incidents arising from the circumstance that the teachers were all White and the students a mix of predominantly African Americans and Hispanics or from tensions between the student groups themselves. I expected that the teachers would describe how they made sure that they were fair to all their students and would give concrete examples. I also expected they would tell how they helped students deal with their differences in order to work together.
But, almost all the teachers in my study—all but Ms. Dombrowski—did not fully address this question. Ms. Dombrowski explained in detail how her students fought with each other and called each other names, how they called her a racist, white girl, and how she resolved those situations. Such behaviors are not related to race alone, and they interfere with an equitable learning environment. It would be hard to believe that she was the only teacher who had experienced these types of events.

Personally, I have experienced similar situations where African American students would accuse me of favoring Hispanics, and times when the Hispanic students would accuse me of favoring African Americans. How I have dealt with such accusations has always been to treat them seriously no matter how frivolous they might have sounded. I addressed them in a sober and deliberate manner with the entire class and privately with the individual accusers. If the student had been just mouthing off to get a rise from me or attention from the other students, my treating it seriously gave the message that these are matters of importance in the classroom and deserving of attention. If it was the case that the student had actually perceived me as being biased in some way, this serious treatment cleared the air. To my eyes, it is important to address matters of equity as they occur because it is possible to be biased without realizing or intending it. Talking about or asking a person about issues that might pertain to equity and racism have been a taboo in the U.S., and some people tend to avoid it completely (see Halliwell, 2015, Malott, 2011, Ofobike, 2006, & Sue, 2015). So I understand why White teachers might be reluctant to write about or discuss matters of equity, because they may have trouble separating them from racism and might feel accused of racism by the question simply because they’re White. My sympathy around this was aroused as they talked
about their experiences during the face-to-face interviews, since the evidence was that these were teachers who were devoted to equity and were going beyond what might be expected in trying to be fair and to do what was best for their students of color.

**Summary of Findings**

- Students’ interest in science trended from very interested to less interested as they moved up the grade ladder from middle school to high school.
- Using teachers as participants rather than students was a shortcoming of the study and did not reveal how useful the conceptual framework might have been with a student sample.
- Some aspects of the questions, such as the decreasing interest as students age, were well answered by the data. However, some aspects were not fully answered, and a follow-up study of student participants that explored issues of race, class, and equity could probably illuminate additional aspects of students’ attitudes.
- Teachers reported that students understood the importance of science to society but did not think they were the ones to do science.
- Almost all the teachers had been interested in science since childhood.
- Teachers saw the importance of STEM/STEAM for the future of their students so did their students, but the students felt that it was for someone else to do it.
- Administrative, parental, and community support of schools and science in particular was seen to be very important by the participating teachers.
- Tracking was practiced only in high school.
• Middle school teachers felt that boys were eager to participate in science activities without fear of judgement when they made mistakes, but girls, on the other hand, were very cautious—they wanted to get it right.

• The question about equity did not produce enough data, especially from high school teachers, because it was a touchy subject for them.

**Limitations and Recommendation for Future Research**

The strength of qualitative studies is that they allow researchers to understand a phenomenon from the perspective of the people who are living the phenomena. Conducting a qualitative study allowed me to explore in-depth the tensions, challenges, opportunities, and frustrations in teaching science from the perspective of those who actually teach the subject day in and day out. The study results shed light that might be helpful for educators who practice in similar school settings and who work with comparable types of student populations. However, for educators practicing in different educational settings with different student populations the findings of this study might not be relevant. This is one of the recognizable limitation of qualitative research; that is, as a researcher you are limited to what data the participants are willing to extend themselves to provide. For example, none of the participants in my study was willing to take more time to answer any question after the initial data collection, and none of them was willing to do member checking. The study was conducted during the teachers’ summer holiday, and that might be one thing to avoid. But again, during the school year teachers are very busy.

In my study the majority of the participating teachers were Caucasians. It could be improved on by having more ethnically diverse teachers to participate. It would be
interesting to see what perspectives teachers of other ethnicities might provide. Another option for consideration is to do a similar study with equal percentages of students from both ethnic groups—African American and Hispanic—and use students as participants. This way the data would come directly from the students instead of data about students coming through their teachers. Issues of race were impossible to capture from teachers but it would be possible if the participants were students. Furthermore, students’ attitudes toward science could possibly be due to class differences more than race. This could be explored with student participants. It could be interesting to find out what type of role models students have in their own communities. Certainly every ethnic group in America has successful individuals, but it is rare that the successful people will live in inner city neighborhoods. This could be another area of research.

As a recommendation, a researcher must allow plenty of time for the project, because a lot of unexpected problems happen. For example, I tried requesting more information from some of the teachers, but they did not respond even though during interviews they had agreed to be contacted for more information and follow-up. I wanted to do a member-check for clarification of the data that I collected, but none of them was willing to do it. They promised to call me back about it, but they did not. That surprised me, because the participants in my study were amazing teachers. My speculation about that behavior was that they might have felt that they were doing me a favor to have agreed to participate since I was truly desperate, and that may have put a limitation on how much of their time they were willing to give to me.
Epilogue: My Research Journey

As a first time researcher, I could not have prepared myself enough to face rejections of my proposal by the IRB of the school district where I worked. I had taken things too much for granted. I thought that my research would be a contribution to the school where I teach and to other schools in the district that have similar student populations. To be told that my research would cause disruption to students’ learning and to their teachers, and that this outweighed the benefit to the district, crushed my spirits. At that time I thought the idea of getting the doctoral degree was over, until I spoke to my advisor and members of my committee, who came up with the idea that I could use the teachers as my study sample and leave the students out of it. Unbeknown to me, the period to submit another permission request to the IRB was over for the school year. Some area schools were closed for the summer by this time, which meant that I could not even try to request permission from other school districts. Another road block.

I must also mention another adventure I experienced trying to find appropriate participants to participate in this study. My coworker suggested interviewing his mother and her church group, a majority of whom were retired science teachers. I was rejuvenated once he asked his mother and she agreed, offering to recruit the rest of the teachers from her church for me. This was like a door had just opened after the district door had closed. Things were looking up for me, but the excitement did not last. The first two participants requested that I visit them after I had emailed them the study surveys. When we met, the two church ladies were excited to see me. I was equally excited until they told me that they wanted to get acquainted first, and wanted me to join them at their church for a service. Not only that, but they would prefer that I attend church every
Sunday and then conduct my study tasks after the service. I tried to budget my time to see if this was going to be possible. The church was at least 45 minutes’ to an hour’s drive for me, and then the service would take about two hours. I did not know if this was going to work, but I saw no other option at the time.

Then I remembered that a local university had invited me to join a summer workshop on looking at the next generation science standards. I had not accepted the invitation because I thought I would be busy with data collection for my study. The date for the workshop was just a day away, but I decided to show up and see what happened. That is when a real door of opportunity opened for me, because the teachers who attended the workshop agreed to participate in my study. I knew then that there was a possibility of finishing this degree. I would have to commit to attending the workshop for the entire week, but it was nothing compared to what I got in exchange. I finished collecting data in a week and a half, the time well spent. These teachers were remarkable. They understood what I was up against. They did not hesitate to contribute, taking it as if it was a duty put upon them to complete. Yet, as I have said above, I could tell by body language during interviews that some felt I was asking too much of them. I understand. The younger teachers, two of whom were in their 20s, wanted to do it and finish as soon as possible so as to have the remainder of the summer to themselves. These younger teachers were forthright, sharing information from their experiences without any hesitation. Older teachers were very cautious about what they said, especially during interview sessions. What I learned from this experience is that to do research requires a lot of time and preparation. Nothing can be taken for granted.
In concluding this journey I would like to mention the following for my fellow science teachers out there. We strive to cover the syllabi, and work hard to push those scientific concepts to see that our students get them. Based on what I have learned from this study, I will now take a step back and let students work in small groups, let them get it wrong—it is okay—and curtail lecturing and long scientific readings. I will allow them to have fun now and then. If the data collection had not taken place in the summertime, I am afraid it would have been very difficult for me to be able to teach my students at the same time, so things worked out just fine after all.
REFERENCES


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Appendix A

IRRB Documents

**IRRB Narrative**

**Statement of Affiliation:** My name is Caroline M. Makere. I am a doctoral candidate at National-Louis University. My student ID #: N00189169.

**The Purpose of the Study:** The purpose of the study is to investigate on minority high school students’ interest in science.

**An Identification of the anticipated risks (physical, emotional, social, political, and economic) and benefits to the participants:** There is no anticipated risk of any type to the participants. The participants could request results of the study, and depending on the outcomes of the study participants could benefit in improving their teaching or making some changes to their curricula.

**Participants:** I will have 13: four middle school science teachers and nine high school science teachers, all but one recruited from a summer professional development event at a local university. The participants will answer a questionnaire survey in writing, and send their answers to me. After this I will schedule a face to face interview with each one of them for a maximum of 90 minutes. These interviews could be broken into two sessions of 45 minutes each if that is what a participant would prefer. The place and time where the interviews will take place will depend on each participants’ choice. I will travel to where they want for interviews. All the interviews will be tape recorded. This information is also explained on the consent form that all participants will get and
The data collected will be coded, decoded, and analyzed. Participants have the right to get a transcript of the data if they so choose.

**Participation is voluntary:** All participants will read the consent form, sign and date it before they can participate in the study. The consent form explain clearly that their participation is voluntary, and even after they have chosen to participate they can withdraw any time without any recourse.

**Confidentiality:** All participants are informed about confidentiality on the consent form and that their names, names of their schools will not be used. Further, the collected survey questionnaires including the audio tapes will be safely kept in locked cabinet by myself.

**Data protection:** All data collected will be stored in my personal computer and there will be no visual recordings but audio. These recordings will be properly destroyed after the study is completed and degree awarded.

**Sharing results with participants:** It is clearly explained on the consent form that participants will receive a transcripts of their data if they would want.

**Who to contact in case participants have questions or concerns about their rights:** The consent form which is in appendix B explains who participants could contact, individuals’ names, their positions, telephone numbers and email addresses.

**Attachments:**

- Consent form
- Questions for participants
Certification

I certify that I have read and understand the policies and procedures for research projects that involve human participants and that I intend to comply with University Policy. I understand that all non-exempt projects require annual review. Significant changes in the study protocol need to be submitted on a Change of Status of Continuing Research Form for review prior to those changes being put into practice.

Signature of Researcher(s)  

Date: 6/17/2016

Check only one of the following, indicating the category into which this research falls according to Title 45, Code of Federal Regulations, Part 46:

XF Project is exempt.

Cite exempt category number from page 3: 406.101b 2

☐ Project is referred for expedited review.

Cite expedited category number from page 3: (Please choose)

☐ Project is referred for full IRRB review.

All research requires the full review of the IRRB unless it meets criteria specified on page 3 of this form.

Approval Signatures

Committee Chair/Primary Advisor

Print Name: Efrat Sara Efron

Signature: Efrat Sara Efron  

Date: 4/18/2015 6/23/2016

IRRB Representative*

Print Name: 

Signature:  

Date: 

*If one individual holds both positions, the Chair/Advisor of committee should request another Director or senior faculty member to review and sign this certification.
July 13, 2016

Caroline M. Makere  
Chicago, IL 60645

Dear Caroline M. Makere:

The Institutional Research Review Board (IRRB) has received your application for your research study “Minority High School Students’ Interest in Science: An Exploration of Levels and Causes”. IRRB has noted that your application is complete and that your study has been approved by your primary advisor and an IRRB representative. Your application has been filed as Exempt in the Office of the Provost.

Please note that the approval for your study is for one year, from July 13, 2016 to July 13, 2017. At the end of that year, please inform the IRRB in writing of the status of the study (i.e. complete, continuing). During this time, if your study changes in ways that impact human participants differently or more significantly than indicated in the current application, please submit a Change of Research Study form to the IRRB, which may be found on NLU’s IRRB website.

All good wishes for the successful completion of your research.

Sincerely,

[Signature]

Shaunti Knauth, Ph.D.  
Chair, IRRB
Appendix B
Participant Consent Form

Informed Consent

My name is Ms. Caroline Makere, a doctoral candidate at xxxxxxx University. I am asking you to participate in my study titled, “Minority high school students’ Interest in Science: An Exploration of Teachers’ Perceptions.” This study will take place in June and July, 2016. The purpose of the study is to investigate on minority students’ interest in science. I would like to find out what science subjects students like and what they dislike, and also the units within a subject and not necessarily the entire subject that they like or dislike and why. This study will help me improve my teaching and hopefully you and other teachers who might find it useful. By signing at the end of this form you are providing consent to participate in a research project conducted by me, Ms. Makere, doctoral candidate, at xxxxxxxx University, xxxxxxx.

Please understand that the purpose of the study is to explore science interests by minority high school students. This is not an attempt to evaluate your teaching methods in any way or form. Participation in this study will include:

- Period for data collection will be between June 20th and July 20th, 2016.

  First, I will send you some questions by email for you to respond in writing, and send them back to me electronically. If this method is unacceptable to you, I will send the survey questionnaire in a method you prefer.

  Secondly, I will schedule a day and time at your convenience to have an interview that will be audio recorded. This interview will take a maximum of 90 minutes, however it can be split into two days for 45 minutes each if that will work better for you. In short, we will agree when and where I will interview you, and this will be at your preference.

  You may request the interview transcripts for your review and approval.

Your participation in this study is voluntary and can be discontinued at any time without penalty or bias. The results of this study may be published or otherwise reported at conferences, and employed to inform all stake holders in education but your identity will in no way be revealed (data will be reported anonymously and bear no identifiers that could connect data to you, your school or your students). To ensure confidentiality I will secure recordings in a locked cabinet, and transcripts in my personal computer. Raw data will be destroyed after they have been utilized in my dissertation.
There are no anticipated risks or benefits, greater than that encountered in daily life, and as mentioned above, you can withdraw from this study at any time without any repercussions.

Upon request you may receive summary results from this study and copies of any publications that may occur. Please email me at xxxxxxxxxxxxx to request results from this study. You can also reach me at xxxxxxxxx if you have any question or for any other reason.

If you have any concern or questions, before, during, or after participation, that I have not addressed you may contact my supervisor, Dr. xxxxxxx at xxxxxxx. Please, feel free to contact the co-chairs of xxxxxx Institutional Research Review Board, Dr. xxxxxxxxx at xxxxxxxxxx or call her at xxxxxxxx. You may also reach xxxxxx xxxx at xxxxxxxxxx or xxxxxxxxx. The co-chairs are located at xxxxxxxx University, xxxxxxxxxx, xxxxxxx, xx.

Thank you so much for your consideration.

Participant’s Signature _____________________________ Date ___________________

Researcher’s Signature _____________________________ Date___________________
Dear Colleague, I am working on finishing my doctoral degree. My topic is on exploring interest in science by minority (African Americans and Hispanics) students. The topic for my study developed from my own experience teaching science in my district for almost 13 years to date. My intention is to find out what your experiences have been in teaching science to minority students.

I thank you, in advance, for the data that you will share with me by answering the following questions as thoroughly, and in depth as you can. I will also appreciate if we can meet in person for a taped interview after you respond to these questions. We can meet once for 90 minutes or twice for 45 minutes each, at your convenience and at your chosen venue.

Note: You can answer in this form by creating space after each question or you can create a separate document so long as you adhere to the parts and question numbers.

Part 1: Teacher demographic information

0. Your name: ________________________________ 0. NAME
1. Your age: _________________________________ 1. AGE
2. Ethnicity: _________________________________ 2. RACE & ETHNICITY
3. Years of experience as a teacher: ____________ 3. EXPERIENCE
4. Years of experience as a science teacher: ________ 4. SCIENCE EXPERIENCE
5. Highest degree that you hold: _________________ 5. TEACHER EDUCATION
Part 11: Personal questions about interest and attitude to science

Did you study to become a science teacher? Why? Or did you switch to science after teaching other subjects. Please explain

How & when did you get interested in science?

Why is science important to you?

III. School Information

Do you teach middle school or high school?

Geographically, where is the school located?

How many students are in your school?

What are students’ ethnic percentages?

How diverse are the classes you teach?

What grades do you teach?

What percentage of your students receive free lunch?

What is the parents’ educational levels/SES?

Do parents and community support science? How?

Do administrators support science? How?

Does the school use tracking? For example, do you have regular, honors, AP, IB, etc. tracks in science? If you do, which one(s) do you teach?

Are students involved in science clubs? Explain
21 Do students participate in science fairs? If they do, how is science fair organized? Is it voluntary or mandatory?  

22 Do students take field trips that are of scientific nature?  

23 What is your school graduation rate?  

IV: Teaching/Learning experience in science  

The following topics are covered in high school biology curricula, even though not exclusively. They are: Introduction to biology, chemistry of life (some might call it biochemistry), cell biology, body systems, DNA and protein synthesis, genetics and reproduction, evolution, taxonomy, ecology, zoology, anatomy & physiology, botany, forensics, etc.  

24 Which of the topics mentioned above do you teach or have taught? You can mention what you teach if it is not among those.  

25 Which of the topics that you teach have interested your students the most? Please explain how they expressed their interest in the topics.  

26 Which of the topics you teach are not interesting to your students? Can you include your explanations on what they said, or how they showed that they were uninterested?  

Many high school curricula teach the following physical science subjects: chemistry, physics, physical science, environmental science, Earth and space science, astronomy, etc.
27 Do you teach any of the subjects in physical science? If not one of these, please say what you teach.

28 Which of the subjects/topics you taught were the most interesting to your students? Explain.

29 Which of the subjects you taught were uninteresting to your students? Explain.

30 How important is STEM/STEAM ([Science, Technology, Engineering, and Math] “A” in STEAM stands for Art) to you, and to your students? Why?

V. Interest/Motivation/Attitudes to science

1. Do you think your students, in general, are interested in science? Please explain your answer and provide examples or anecdotes from students.

2. Have you noticed differences in science interest by gender of your students? Please explain.

3. If you teach multiple grades, have you observed students’ interest in science to increase or decrease with age? Please explain.

4. During your teaching career, have you ever asked students about their future plans for science? Explain

35 Have students indicated that they will major in science when they go to college? Please explain.
36 Have students indicated that they will seek careers in science? Become scientists? Please explain.

37 What do you think about your science curricula at your school? Do you have any say about what is to be included/excluded? Please explain.

38 Do you tap into cultural knowledge of your students’ ethnicities to help motivate/engage them in science? Please explain.

39 Are there specific strategies that you use to motivate/engage students in captivating their interest in science? Please explain.

40 What strategies do you use to dismiss negative attitudes or misconceptions students hold on some scientific concepts?

41 How do you make sure that you treat all of your students fairly? And, how do you make sure that students treat each other fairly? In general, how do you make sure there is equity in your classrooms?

42 Has any historical scientific theories come up in your teaching that you had to address to dispel myths, stereotypes, stigma, and prejudices in science? If you have, could you please explain?