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Attitudes, Interests, and Perceived Self-efficacy toward Science of Middle School Minority Female Students: Considerations for their Low Achievement and Participation in STEM Disciplines

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Attitudes, Interests, and Perceived Self-efficacy toward Science of Middle School Minority Female Students: Considerations for their Low Achievement and Participation in STEM Disciplines.

A dissertation submitted in partial satisfaction of the requirements for the degree Doctor of Education in Educational Leadership by

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Katherine Hayden, Chair
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2013
The Dissertation of Ana L. Dowey is approved, and it is acceptable in quality and form for publication on microfilm and electronically:

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Chair

University of California, San Diego
California State University, San Marcos
2013
DEDICATION

This dissertation is lovingly dedicated to my husband, Kent and my children Erik and Andrew, whose support, encouragement, and constant love has sustained me throughout our life together.
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1987-1989 California Laboratory Scientist, Torrance Memorial Medical Center

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Educational Leadership
Main Fields of Interest

Minority Participation in Sciences and Outreach
ABSTRACT OF THE DISSERTATION

Attitudes, Interests, and Perceived Self-efficacy toward Science of Middle School Minority Female Students: Considerations for their Low Achievement and Participation in STEM Disciplines.

by

Ana Lucrecia Dowey

Doctor of Education in Educational Leadership

University of California, San Diego, 2013
California State University, San Marcos, 2013

Katherine Hayden, Chair

The underparticipation of minority females in STEM fields has been a chronic problem in the United States, mainly when it is analyzed through the lens of their relative representation in the population. The results of the first or quantitative phase, of this two phase sequential, mixed method study, revealed academic achievement or performance in science accounted for most of the variance of mean scores for students’ attitudes and interests in science as measured by the TOSRA Likert-scale survey, when compared to...
the degree of parent education and ethnicity/racial background. Additionally, this study investigated possible sources of perceived self-efficacy in eighteen seventh grade Hispanic female students by conducting personal semi-structured interviews. The purpose of this study was to explore if middle school female student ethnic/racial backgrounds and academic performance influence their attitudes and interests toward science and to study the possible effects external (family, school, peers, and community) and internal factors may have for Hispanic student self-efficacy toward science.

The results revealed that of the five ethnic/racial groups studied, Asian/Filipino female students expressed higher positive attitudes and interests toward science, than the rest of the student ethnic groups studied, followed by the Hispanic student group. The results indicated that students’ perceived encouragement from their mothers, regardless of the mother’s degree of education, as being the main source of these girls’ perceived self-efficacy in science. However, the lack of perceived school-related, peer-related, and community-related support was evident. These results are encouraging because they demonstrate how verbal persuasion, in the form of encouragement and support, fosters perceived self-efficacy for minority female students.
CHAPTER ONE: INTRODUCTION

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)_

**Statement of the Problem**

A well-prepared and diverse workforce in science, technology, engineering, and mathematics (STEM) is central for the nation to remain innovative and competitive in today’s global market. Although in the U. S. women fill half of the jobs in the labor market, they remain markedly underrepresented as STEM degree and occupation holders. As of 2011, women held fewer than 25 percent of all STEM jobs in the U. S. (U.S. Department of Commerce, 2011).

Regardless of the great strides made by women in the last 30 years at narrowing the “gender gap” in STEM disciplines, an important and worrisome “intra-gender” academic achievement and labor gap still persists (National Center for Education Progress NCES, 2009). Women of certain ethnic/racial backgrounds —specifically African American, Hispanic, and Native-American— continue to underperform compared to their peers within the same gender (American Association of University Women AAUW, 1998; Brickhouse & Potter, 2001; Gilbert & Calvert, 2003).

The underrepresentation of women and especially underrepresented minority women in STEM fields is not a new problem (Blickenstaff, 2005) or a new topic in
science policy research (Leslie, McClure, & Oaxaca, 1998). Cronin and Roger (1999) describe this low participation as both “progressive (the farther along the pipeline, the fewer women you find) and persistent (the problem has not gone away in spite of treatments)” (p. 639).

This issue becomes critically relevant when it is studied in the context of the dramatic demographic shift the United States has undergone during recent decades. Between 1980 and 1990, the Hispanic population grew more than seven times as fast as the rest of the nation (U.S. Census Bureau, 1993), and these numbers are projected to double, from 39.3 million in 2010 to 80.7 million in 2050 (U.S. Census Bureau, 2009). Students of Hispanic descent made up 17 percent of the K-12 student population in 2002, and it is predicted that by 2025, they will comprise about 25 percent of the total student population (U.S. Census Bureau, 2009). Hispanic female students make up a significant portion of the minority student group, and they are becoming the nation’s fastest growing minority group (U.S. Census Bureau, 2009). In 2000, they comprised approximately 25 percent of the United States total female population (Latino Coalition for a Healthy California, 2000).

These numbers alone could represent an important source of human capital and could be a potential and rich source of the nation’s future scientists. Consequently, it is of critical significance to study the barriers responsible for the “intra-gender” disparities in academic achievement and the low participation of minority females in STEM.

Most of the data on academic achievement of female students of different ethnic/racial backgrounds is usually reported in an aggregated form—clustered under the
“Underrepresented Minority” (URM) designation. These types of data fail to reveal the seriousness of the factors that predispose the underrepresentation of these individuals in various scientific fields (Catterall, 1998; Nettles & Pleck, 1994; Richters & Weintraub, 1990; Von Secker, 2004) and constrain comparative studies of different ethnic groups. Disaggregated data then, becomes necessary in order to gain knowledge into the possible factors responsible for the disparities seen in academic achievement among these female student groups.

For students in the U.S., there is no single pathway to STEM education. Students come from varied academic, school, community, and family background (NAS, NAE, & IM, 2011). However, the student educational years leading to a STEM profession is illustrated as a continuum, from the early school years to the doctoral level. In this study, the term “pipeline,” as suggested by Solorzano, Villalpando, and Oseguera, (2005, p. 279), will be employed in the context of a student’s educational years towards a science, technology, engineering, and mathematics (STEM) profession. There is indication that the gender and ethnic/racial gap in science achievement appears early in schooling, with significant gender differences favoring males already evident as early as age nine (Mullis, Dossey, Owen, & Phillips, 1993). Although the differences are initially small in middle grades, gender differences in science achievement become more substantial as students progress through high school (Jones, Mullis, Raizen, Weiss, & Weston, 1992). Males continue to show significantly greater gains than females in science achievement throughout the schooling process (Kahle, 1996), and males continue to take more science courses, including more advanced science courses, at the high school level than do
females (Scott, Rock, Pollack, Ingels, & Quinn, 1995). By age 17, when students are typically in grade 12, gender differences in science achievement are larger than at any other age (Drew, 1996).

The middle school years are a critical period for American students’ achievement in mathematics and science. Their performance in these subjects in middle school determines high school choices and enrollment in higher level mathematics and science courses. In addition, their early interests and positive attitudes toward mathematics and science have also been related to educational and career aspirations in these disciplines (Singh, Granville, & Dika, 2002). By the time students reach high school, they have already decided whether to pursue advanced mathematics and science courses, with many of these decisions being based on earlier success in these subjects.

The precollege years represent a critical period for encouraging students to enter the science pipeline (Muller, 1998). African American, Hispanic, and Native American female students have shown, up to now, low levels of science and math preparation coupled with low achievement levels of precollege course achievement. Most importantly, these trends consistently have been reported to be among the best predictors of students’ interests and persistence in science and engineering during postsecondary college, and even at the doctoral level (Baruch & Nagy, 1977; Maple, 1994; Astin & Sax, 1996; Drew, 1996; Hanson, 1996; Stage & Maple, 1996).

Multiple researchers have studied the factors responsible for academic disparities; yet the problem persists. Levels of attitudes, interests, and self-efficacy have been used as frameworks to explain differences in student academic achievement and performance
In social psychology, attitudes are defined as learned tendencies to evaluate things a certain way. Such evaluations are often positive or negative, but they can also be doubtful at times. Researchers suggest that there are several components making up attitude, such as an emotional component, how the object, person, issue, or event makes you feel; a cognitive component: your thoughts and beliefs about the subject; and a behavioral component: how the attitude influences your behavior (Zimbardo & Boyd, 1999).

According to Hockenbury and Hockenbury (2007), while attitudes can have a powerful influence on behavior, they are susceptible to change. The learning theory on attitude formation and changes suggests persuasions and vicarious experiences can be used to bring about attitude modification.

Learning accounts for most of the attitudes one holds. Theories of social learning are mainly responsible for formation of attitude. Unlike personality, attitudes are expected to change as a function of experience and persuasion (Hockenbury & Hockenbury, 2007). Studies provide evidence positive attitudes foster science achievement and career interests by increasing the likelihood students will enroll in advanced science courses and engage in future activities associated with life-long science learning (Carey & Shavelson, 1988; Mason & Kahle, 1989; Norwich & Duncan, 1990).

The emotion of interests, in psychology, is argued to be a cornerstone of human development. Vocational psychologists have explored how feelings of interests contribute to beneficial vocational decisions and optimal work environments (Roe &
Siegelman, 1964; Savickas, 1999). Being interested in something is simply another way of expressing enjoyment in the activity (Lewin, 1935). Research on intrinsic motivation makes a similar assumption; interests initiates exploratory activity, and enjoyment sustains the willingness to continue the activity. Consistent with this reasoning, Reeve (1989) found feelings of interests and enjoyment had different causes. Interests came from a task's stimulus features—novelty, complexity, and so on—whereas enjoyment came from competent performance of the task. Self-efficacy is the belief in one’s ability to organize and to execute the courses of action necessary to perform a specific task or goal (Bandura, 1997; Pajares, 2005; Zimmerman, 2000).

The development of this belief in one’s abilities—specifically in science—is contingent on several external factors because learning is not only an individual but also a social activity. The incentive for acquiring new information and skills does not only emerge from intrinsic interests in content, but it also emerges from the desire to contribute as a valued member of a community (Olitsky, 2007). Consequently, fostering self-efficacy in science can be a combined social, family, and school pursuit.

In summary, attitudes and interests in a domain are malleable emotions, which can affect perceived self-efficacy. Therefore, if these beliefs can be positively influenced, in turn, perceived self-efficacy in the specific domain can be increased. This study explores the possible differences in attitudes, interests, and perceived self-efficacy toward science among middle-school female students of different ethnic/racial backgrounds and investigates the effects of external and internal factors, which foster such academic constructs.
Given the increasingly technological and research-oriented scientific nature of our society and global community, if disparities in science education, achievement, and participation continue, it will dramatically widen the gap in our society between the haves and have-nots, the elite and the excluded. For these reasons, the inclusion of women, people of color, and the poor, is critical to increase not just the quantity, but the quality and breadth of the talent of individuals in STEM fields (Drew, 1996).

**Purpose of the Study**

Several studies have looked at attitudes, interests, and self-efficacy as mediators of student performance and motivation in science (Betz, 2000; Britner, 2000; Christidou, 2011). However, there is still much to learn about the specific external and internal factors which contribute to the persistent “intra-gender” achievement and participation gap in science among middle school female students from different ethnic/racial backgrounds. Therefore, the purpose of this study is to explore if middle school female student ethnic/racial backgrounds and academic performance influence their attitudes and interests toward science and to study the possible effects external (family, school, peers, and community) and internal factors may have for Hispanic student self-efficacy toward science.

The findings of this study will assist school leaders, teachers, and parents in learning about the most effective practices and specific strategies for developing students’ positive attitudes, interests, and self-efficacy in STEM subjects.

**Research Questions**

This investigation attempts to answer the following research questions:
1. To what extent do attitudes and interests toward science differ among adolescent middle school, female students of diverse ethnic/racial backgrounds —African American, Asian/Filipino, Hispanic, and Caucasian?

2. What are the correlation levels between favorable attitudes and interests toward science and academic achievement of middle school female students after controlling for other external factors such as parental education level and home language?

3. In what ways do external factors have an effect on Hispanic middle school female students’ perceptions of their self-efficacy, attitudes, and interests and personal aspirations of pursuing a career in science?

Research Hypotheses

The research hypotheses for this study are centered on a combination of two theoretical foundations, social cognitive theory (Bandura, 1986) and cultural-ecological theory (Ogbu, 1981). They were formulated to build upon earlier research results related to self-efficacy, interests, and performance in science in educational settings.

The research hypotheses were as follows:

1. The ethnic/racial background of middle school students will align with the positive levels of attitudes and interests toward science.

2. Mean scores in levels of positive attitudes and interests toward science of middle-school girls based on their academic achievement in science will not significantly differ among ethnic/racial background of groups.

3. Perceived self-efficacy, attitudes, interests, and aspirations about pursuing a science
career of middle-school girls will be influenced by external factors such as verbal persuasions and vicarious modeling.

**Significance of the Study**

The analysis of minority female student attitudes, interests, and perceived self-efficacy in the science domain is important to study for several reasons:

1. Knowing and understanding the impact of positive levels of female student attitudes, interests and perceived self-efficacy in science could help teachers and school officials assess and implement to their current educational practices. In particular, teachers may develop specific pedagogical practices in their classes to increase student perception and enjoyment of science.

2. Assist and support parental involvement in the development of a robust self-efficacy in science for their daughters by informing them about the most efficacious practices which contribute to the development of strong positive self-efficacy in science abilities.

3. Identify effective practices within families, society, and school environments, which foster minority female middle school girls’ self-efficacy in science and increase their participation in STEM disciplines.

**Limitations**

One limitation of the study was that the sample included only seventh grade female students decreasing the generalizability of results. A second limitation of the study was the use of the end of the academic year grade point average (GPA) as the measure of science achievement to be measured against attitudes and interests toward
science. Grading practices vary from teacher to teacher and are not standardized. A standardized science test score was not available for seven grade students. Standardized science scores are only available in California for fifth, eighth and tenth grades.

A third limitation of the study was the self-reporting of ethnicity done by students in the survey. When reporting mixed ethnicity, an individual can identify with one population more than the other. A fourth limitation of this study was researcher bias, which may have entered into the phenomenological interpretation and construction of meaning of the semi-structured interview.

Methods Overview

This study uses a sequential explanatory mixed methods design (Newman & DeMarco, 2003). This type of study is characterized by the collection and analysis of quantitative data followed by the collection and analysis of qualitative data. The purpose of the sequential explanatory design is typically to use qualitative results to assist in explaining and interpreting the findings of a primarily quantitative study. The quantitative results can then be used to guide the purposeful sampling of participants for a qualitative study.

The association between attitudes and interests toward science and a measure of science academic achievement was quantitatively studied through survey research methods administered to 284 seventh grade female students. The sequential second phase of the study was a qualitative method with semi-structured personal interview design with 18 Hispanic seventh grade females from the high and low academic achievement range in science. This phase gathered in depth information about this ethnic
group of students’ external and internal sources of self-efficacy toward science that could explain their attitudes and interests in science. All data sources were then considered for triangulation to increase the study’s validity.
CHAPTER TWO: LITERATURE REVIEW

The limited participation of minority women in STEM careers in the United States is a critical problem in need of attention. This study explores the attitudes, interests, and perceived self-efficacy toward science of middle school female students of diverse ethnic/racial backgrounds in an effort to shed light on the possible reasons for their underrepresentation.

Importance of STEM

STEM as defined by the American Association of University Women (AAUW) refers to the physical, biological, and agricultural sciences; computer and information sciences; engineering and engineering technologies; and mathematics (AAUW, 2010). All STEM disciplines are considered critical to the national economy. Concern about America’s ability to be competitive in the global economy has led to a number of calls to action to strengthen the pipeline\(^1\) into these fields (National Academy of Sciences, Committee on Science, Engineering & Public Policy, 2007; U.S. Department of Education, 2006). Expanding and developing the STEM workforce is a critical issue for government, industry, and education.

Researchers have calculated that as of 2006, only about five million people (about four percent of the nation’s population) worked in STEM fields (National Science Foundation, 2008); however, the U.S. Department of Labor has projected that mathematical training. Many science and engineering occupations are predicted to grow

\[^1\] Pipeline is a metaphor for the educational path carrying students from secondary school through university and on to a job in STEM (Blickenstaff, 2005).
by 2018, nine of the 10 fastest-growing occupations will require significant scientific or faster than the average rate for all occupations and some of the largest increases will be in engineering- and computer-related fields—fields in which women currently hold one-quarter or fewer positions (Lacey & Wright, 2009; National Science Board, 2008).

Regardless of whether predictions of shortfalls of quality human resources are accurate, attention has focused on the composition of the talent pool available to do science given the underrepresentation of women and racial-ethnic minorities (Hilton & Lee, 1988). In addition, given the increasingly technological nature of our society, disparities in science education participation will dramatically widen the gap between the haves and have-nots, the elite and the excluded.

Drew (1996) reported the underrepresentation of women, people of color, and the poor decreases, not just the quantity, but the quality and breadth of the talent of persons in science, mathematics, and engineering fields.

**Hispanic Student Academic Achievement**

The education of Hispanics in the U.S. has long been characterized by high dropout rates and low college completion rates. Both problems have moderated over time, and across generations, though a persistent educational attainment gap remains between Hispanics and non-Hispanics (Fry, 2009). Despite some promising signs of advancement, the average Hispanic high school student continues to lag behind other ethnic minorities and Caucasians on most measures of success, including educational attainment and its extension, economic well-being (Adelman, 1999; Secada, Chávez-Chávez, García, Muñoz, Oakes, Santiago-Santiago, & Slavin, 1998). On average,
Hispanic students are roughly two to three years in learning behind Caucasian students of the same age (Baker, 2002).

Hart and Risley (1995) argue, the achievement gap for Hispanic students actually starts at infancy—well before they start school. On average, Hispanic students enter kindergarten with lower skills in reading and mathematics than their non-Hispanic Caucasian counterparts (Reardon & Galindo, 2008). Four-year-old Hispanic children have lower rates of proficiency in letter recognition compared with four-year-olds of other racial/ethnic groups according to the National Center of Educational Progress (NAEP, 2009), and their deficits in vocabulary preparation are significant (Hanushek, 2010). These early-life gaps in letter recognition and vocabulary preparation could have lasting effects on student educational outcomes (Hart et al., 1995).

Taking the average scores for math and reading across the fourth and eighth grades in 2003, for example, 43 percent of Hispanic students scored “below basic,” while only 17 percent of Caucasian students scored as low across states (National Center for Educational Progress NCES, 2003). This gap comparison was consistent in both achievement and attainment measures. One of the latest reports on Hispanic student scores placed them within the lowest quartile range of the Caucasian achievement score data (NCES, 2003). Furthermore, several researchers point out high school completion rates for Hispanic students have been shown to be substantially lower than either Caucasian or African American students (Kaufman, Alt, & Chapman, 2001; Padron, Waxman, & Rivera, 2002; Perreira, Harris, & Lee, 2006), and these students are less likely to attend and graduate from college (Cameron & Heckman, 2001; Stoops, 2004).
The U.S. Department of Education report on the condition of education, through the National Center for Education Statistics (NCES, 2009), points out all students’ 2009 science performance showed 34 percent of students at grade 4, 30 percent of students at grade 8, and 21 percent of students at grade 12 were performing at or above the Proficient level. In addition, about 1 percent of 4th-grade students, 2 percent of 8th-grade students, and 1 percent of 12th-grade students were at the Advanced level in 2009. So while this study will focus on the Hispanic female, it is clear students throughout the United States are underperforming in science, and it is hoped through careful examination of the group of interests, this research can provide insights toward factors influencing interests and efficacy in science overall.

**Hispanic Female Student Science Academic Achievement**

One of the most arguable results in adolescent achievement is a correlation not only with gender, but also with race/ethnicity (Von Secker, 2004). The academic performance disparities of underrepresented minority (URM) females — African American, Hispanic, Native American, and Pacific-Islander — in the United States has reached a critical mark on educational scales when compared to their Asian and Caucasian peers. Of particular significance are Hispanic females who comprised the largest minority group within the nation’s population and the fastest growing group of female school-aged youth in the United States (Fry & Gonzalez, 2008). In California, for instance, Hispanic females comprise 25 percent of the female population; yet 61 percent of Hispanic females, aged 25 to 44, never receive a high school diploma, 24 percent are high school graduates, and 15 only percent have gone on to postsecondary education (Latino Coalition for a Healthy California, 2000).
The profile of URM females of high school age has not shown any considerable improvement in recent years. For example, results published by the California Postsecondary Education Commission (CPEC, 2010) for 2008-09, revealed, in California alone, lower percentages of Hispanic females were enrolled in advanced courses than their counterparts. Specifically, Hispanic females enrolled in mathematics (10 percent), chemistry (13 percent), and physics (4 percent) courses were compared to their counterparts: Asian (whose participation was at 36, 24, and 11 percent respectively), and Caucasians (at 12, 16, and 6 percent respectively) (CPEC, 2010).

However disheartening these results are, the nation has seen a remarkable increase in graduation rates for all ethnic female students groups —age 16- to 24-year old —from 1971 to 2008. The percentage graduation rate for Caucasian females during this period increased from 87 to 96 percent, while Hispanic females in this same age group, improved from 70 to 83 (U.S. Department of Commerce, 2008). Pre-college science achievement has been noted for the significant role it plays in the participation of women and students of color in SME fields. Indeed, Berryman (1983) described the underrepresentation of students of color as being largely attributable to their lower levels of achievement in math and science during the precollege years. Women and students of color tend to be less academically prepared in science, as evidenced in coursework and standardized achievement scores. This under preparation in science is generally believed to be an important factor in the underrepresentation of women and people of color in science undergraduate majors, doctoral degrees, and science and technical careers (Drew, 1996). Hanson (1996) argues women's lower standardized math and science scores illustrate how one of the major routes to STEM fields is negatively affected by gender in
students’ science experiences. In addition, as the literature typically notes, the primary cause of attrition of minority students from scientific fields is often poor academic preparation prior to college (Oakes, 1990; Petersdorf, 1991).

In 2001, studies conducted by Muller, Stage, and Kinzie concluded African American and Hispanic students continue to perform far below Caucasians and Asian-Americans in terms of precollege science achievement and the quality of science courses completed in high school was the only stable predictor of science growth rates across all racial/ethnic groups. Hence, they argued, the more precollege science courses taken

<table>
<thead>
<tr>
<th>Ethnic Group</th>
<th>AP Biology Mean Score</th>
<th>AP Chemistry Mean Score</th>
<th>AP Physics Mean Score</th>
<th>Total Test Takers</th>
</tr>
</thead>
<tbody>
<tr>
<td>African American</td>
<td>1.76</td>
<td>1.80</td>
<td>2.00</td>
<td>728</td>
</tr>
<tr>
<td>Asian American</td>
<td>2.86</td>
<td>2.94</td>
<td>2.74</td>
<td>10,931</td>
</tr>
<tr>
<td><strong>Mexican American</strong></td>
<td><strong>1.55</strong></td>
<td><strong>1.55</strong></td>
<td><strong>1.66</strong></td>
<td><strong>3,414</strong></td>
</tr>
<tr>
<td>Native American</td>
<td>2.67</td>
<td>2.11</td>
<td>2.13</td>
<td>89</td>
</tr>
<tr>
<td>Caucasian</td>
<td>3.32</td>
<td>2.85</td>
<td>2.69</td>
<td>4,533</td>
</tr>
</tbody>
</table>

*Note:* Reported by total and ethnic group of female students in California for 2010 as reported. The test is graded 1 through 5 with 3, 4, and 5 score qualifying for college credit.
during high school, the more significant is the growth rate for science achievement. The latest California Advanced Placement science test mean score report, administered in May 2010 (The College Board, 2011) showed the stagnant academic shortfall of Hispanic and African American female students as compared to their peers of the same gender (see Table 2.1 above).

**Hispanic Female Participation in STEM Fields**

Scientists of diverse backgrounds are critical to solving urgent social problems such as finding the cure for fatal diseases including AIDS, malaria, and cancer; creating new sources of energy; generating sustainable crop production with maximum yield to feed the ever-increasing world population; and renewing and maintaining our aging nation’s infrastructure. However, in spite of the emphasis on the recruitment and retention of minority women in STEM, results have proven elusive partly because of the complex sources for URM underachievement in science and math.

The underrepresentation of women and especially underrepresented minority women in a STEM field is not a new problem (Blickenstaff, 2005). Results from a comprehensive study of the educational pipeline from elementary school to the doctorate for the five major racial/ethnic groups — African–American, Asian-American, Caucasian, Hispanic, and Native-American—in the United States, reveals that of the URM, Hispanic students, as a whole, performed the least well at each educational stage (Solorzano et al., 2005).

In 2008, URM females are still underrepresented among science and engineering
degree recipients and their graduate numbers worsens as they progress through the pipeline. Table 2.2 on page 20, illustrates the total number of degrees awarded in science and engineering in 2008 in the United States, with females earning almost half of the degrees at each stage of the pipeline as reported by the NSF for 2008. It is important to note URM degree recipients are still underrepresented in these fields.

Solorzano et al. (2005) illustrate the STEM educational years as a continuum—from the early school years to the doctorate level. Within this pipeline, the gender and ethnic/racial gap in science achievement appeared early in schooling (Mullis et al., 1993). Although initially small in middle grades, gender differences in science achievement became more substantial as students progressed through high school (Jones et al., 1992).

Graduating from high school is a truly significant achievement for a URM female student because along her educational road multiple hurdles had to be overcome. For these females to aspire to and pursue a career in a STEM field, they would need intrinsic and external support sources to achieve these academic aspirations. Many URM students from low educational and social and cultural backgrounds fail to receive the experiences and training that are crucial for success in STEM careers. Such individuals do not succeed in STEM because, in general, they are not as well prepared academically for the rigors of STEM (Seymour & Hewitt, 1997). For example, teachers with neither state certification nor an academic major in teach twenty-two percent of the nation’s public secondary school math courses.
Because postsecondary education is an elective decision, high school students need to be advised of the importance of academic achievement, secondary preparation, and the relevance and benefits of a college education. Once a Hispanic female has chosen to pursue a field in STEM, her retention is critical. Research notes that, in general, the greatest point of attrition in postsecondary enrollment is within the first year of college (Tinto, 1987). Therefore, a third key transition measure, after high school and starting postsecondary schooling is the proportion of entering first-year postsecondary students who enroll for a second year of study.

**Table 2.2:** NSF 2008 Women and Minorities in Science, Engineering, and Math -SEM – report. *Science and Engineering degrees awarded to females in 2008 in the U.S.*

<table>
<thead>
<tr>
<th></th>
<th>Bachelor’s Degrees Awarded</th>
<th>Master’s Degrees Awarded</th>
<th>Doctoral Degrees Awarded</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Total S&amp;E Degrees</strong></td>
<td>496,052</td>
<td>126,395</td>
<td>20,184</td>
</tr>
<tr>
<td><strong>Females only</strong></td>
<td>249,389</td>
<td>57,589</td>
<td>9,476</td>
</tr>
<tr>
<td><strong>Caucasian Females</strong></td>
<td>153,239</td>
<td>28,220</td>
<td>6,500</td>
</tr>
<tr>
<td><strong>Pacific-Islander/Asian Females</strong></td>
<td>23,263</td>
<td>4,073</td>
<td>1,933</td>
</tr>
<tr>
<td><strong>Hispanic Females</strong></td>
<td><strong>23,051</strong></td>
<td><strong>3,364</strong></td>
<td><strong>639</strong></td>
</tr>
<tr>
<td><strong>African American Females</strong></td>
<td>26,229</td>
<td>5,836</td>
<td>594</td>
</tr>
<tr>
<td><strong>Native American Females</strong></td>
<td>1,824</td>
<td>318</td>
<td>56</td>
</tr>
</tbody>
</table>
The underrepresentation of minority women in STEM does not improve in the professional and academic landscape. A significant number of Hispanic females, who receive a bachelor’s degree in science and engineering, do not choose to teach STEM disciplines (Nelson & Brammer, 2010). This trend may prevent future underrepresented minorities from entering STEM fields of study because of the void of Hispanic role models. This is especially true in physical sciences and engineering departments at research universities. Nelson et al., (2010) also found the percentage of Hispanic faculty among assistant professors in the top fifty departments of chemistry and math is lower than among associate professors, indicating a decline in hiring this minority. According to the above-mentioned researchers, minorities are less likely to choose and persist in science and engineering when they lack role models and mentors. This makes critically important that the perpetuation of this cycle be broken as today’s students must be tomorrow’s role models.

Factors Affecting Academic Achievement and Participation of Hispanic Female Students in Science

The question, then, becomes this:

What explains the disparity among Hispanic females and the other Ethnic/Racial Female groups in science fields?

Many researchers on science learning have examined the extent to which different factors affect the participation of Hispanic females in science, including cultural, socio-economic, family, and personally-related factors. It has been found there are an underlying complex relationship between at least two and in several cases many more factors that should be used in modeling the Hispanic student future career path (Vedder-
Weiss & Fortus, 2010). These factors can be examined based on whether they can be
categorized as external, as in family, economic or other structural factors, or internal, as
in personal or psychological factors. The factors which place Hispanic female students at
risk for low achievement are presented here based on their external or internal sources.

**External factors.** External factors are issues and practices in the environment
outside the individual self which have control over them many times, but are out of this
individual’s reach. However, they play a significant role in shaping and fostering
perceived self-efficacy in a specific domain.

**Family-related factors.**

Research conducted by Flynn (2007) found Hispanic parents exhibited lesser
involvement in their children’s education; even though students whose parents were
actively involved in their schooling are more likely to do well academically. This factor
of diminished parent involvement was potentially even greater when applied to Hispanic
female students. In an earlier study by Stevenson and Baker (1987) parents of Hispanic
background were more involved in school activities with their sons and more involved in
home activities with their daughters. This gender difference could contribute both to the
external effects of parent-school relations on Hispanic female academic performance, and
to the child’s perception of her role as a female being supported as a homemaker and not
in academics.

The reasons for reduced parental school involvement vary. Many Hispanic
parents face barriers related to limited English proficiency and lower personal
educational attainment. These factors may hinder some parents’ involvement in their
children’s school-life because of their lower cultural and social capital. In other words,
some parents lack the knowledge of how the education system works, and fail to understand how to gain access to important networks. Consequently, they are prevented from advocating for their children (Gandara & Contreras, 2009). Some Hispanic parents perceive they are unwelcome at their child’s school because of their low English proficiency. For instance, their lack of language skills may prevent them from attending PTA meetings and keeping open communication with their child’s English-speaking teacher (NWLC & MALDEF, 2008). Data reported by Hernandez, Vargas, and Martinez (1994) showed support of the family, schools, and peers was an important factor for Hispanic females completing high school and taking non-traditional career paths.

**Cultural factors.**

In raising their children, parents of diverse ethnic/racial background use beliefs and practices largely determined by their cultural and socioeconomic status (Zayas & Solari, 1994). There is evidence the social capital of particular ethnic groups is significantly advantageous to their children’s achievement (Caplan, Choy, & Whitmore, 1992). For instance, Southeast Asians from refugee families show high academic performance in part because the children tutor one another on their homework. Most of the understanding of the academic success of Asian Americans point to positive cultural beliefs about the benefits of education. Caplan et al. (1992) argued Southeast Asians have a cultural understanding prioritizing self-reliance and achievement. This is not to say other ethnic groups do not value education; however, they may not give education the same priority as Southeast Asians do.
Despite the lower academic performance of Hispanics and their disadvantaged parental socio-economic characteristics, they share some commonalities with Asian Americans. Valenzuela and Dornbusch (1994) suggested that familism, or the valuation of close ties to family members, is an important form of social capital and was associated with higher academic achievement. This can be both a plus and hindrance for female Hispanic students in that often the cultural belief is that women should be the homemaker and take care of the family.

**Social and economic factors.**

Most teachers know about the confluence of ethnicity and gender discrimination to which some Hispanic female students can be subjected to by fellow students which can make them feel unwelcome at school and affect their academic performance and graduation rates (NWLC & MALDEF, 2008). One interesting line of research regarding the relevance of stereotypes examines the relationship between stereotype threat, or the fear of conforming to stereotypes about a subgroup to which one belongs, and women’s poorer performance on math tests. Steele (1997) argued that because of conventional notions men outperform women on standardized tests, especially in mathematics, women experienced a heightened anxiety during test taking, which interferes with their test performance.

There is evidence of connections among poverty, low achievement, and dropout risk (Rumberger, 1995; Rumberger & Rodriguez, 2002). In 2007, twenty-eight percent of Hispanic children lived in poverty compared to only 10 percent of Caucasian, non-Hispanic children (U.S. Census Bureau, 2009). In addition to poverty, Hispanic students were more likely to move and change schools (possibly because of their parents’ fragile
economic situation) than children from other ethnicities. This pattern has been found to bear a negative effect on achievement and to correlate to higher dropout rates among Hispanic students. Moreover, Hispanic students are more likely to live in low-income communities lacking important resources such as playgrounds, parks, and after-school programs; all of which could provide these students with valuable after-school academic support (Rumberger et al., 2002).

The Hispanic student, overall, attends schools with fewer resources and more crowded conditions. In addition, classes are taught by less-experienced teachers and teacher turnover is high, all of which may limit students’ access to more rigorous academic programs or after-school enrichment activities (Gandara et al., 2009). In addition, Hispanic students were less likely than their African American and Caucasian peers to participate in early-childhood education programs. As a result, the Hispanic student often enters school with reading levels lower than their Caucasian peers (Dolan, 2009).

The parent and student immigration status can be a source of instability for children. The parents’ undocumented status produces anxiety and uncertainty as revealed by interviews of focus groups by MALDEC researchers (NWLC & MALDEC, 2008). An often overlooked influence of undocumented status is Hispanic students most often did not qualify for federal financial aid for higher education; as a result, they had less incentive to graduate from high school and go on to higher learning institutions (NWLC & MALDEC, 2008).

**School factors.**

Romo and Falbo (1996) reported school academic counseling may prevent
Hispanic female students from taking advanced courses. Vocational education enrollments clearly showed Hispanic females being steered into jobs with little career or income potential. In Texas, for example, Latina high school students are frequently enrolled in cosmetology classes, and others are tracked into non-college preparatory general education programs. Few vocational programs encouraged Hispanic females to enter non-traditional fields or offered them reasons to remain in school. There is evidence some teachers express low expectations for Hispanic female students (Sadker & Sadker, 1994). From early school through graduate education, the examples of gender bias have been found to be obvious in many of our classrooms.

The lack of role models in the academic life of Hispanic girls has been noted to have a significant influence in their science participation (Smoot, Woods, Ghose, & Perry-Thorton, 2001). Typically, a student decides to become a scientist between 4th and 6th grades. However, minority female students were observed to need early experiences to motivate them to continue to study and participate in science. Programs featuring successful Latina women role models in non-traditional fields have inspired Hispanic females to think about new career options (Hernandez et al., 1994). Likewise, programs targeting Hispanic mother-daughter relationships (Romo et al., 1996) have successfully aimed at high-risk 6th-grade girls who come from families in which no member has graduated from college.

Castillo, Conoley, Cepeda, Ivy, and Archuleta (2010) reported the importance of peer influence in creating a culture of academic achievement. Unfortunately these pro-college behaviors were absent from a group of ninth-grade Hispanic students participating in their research. The most at-risk students reported negative peer influence
and avoiding talking about college. Yet, the least at-risk group stated using peer influence in helping one another as a stimulus for attaining good grades and future college life.

Internal or individual related factors. Psychological factors, which are intrinsic to the student, need to be considered when studying the development of an individual’s academic character and future career choice. A critical problem among an adolescent Hispanic female is a trend toward teenage pregnancy.

The National Campaign to Prevent Teen and Unplanned Pregnancy (2008) reported Hispanic female students have higher rates of teen pregnancy than other ethnic/racial groups of girls. For too many Hispanic girls, teen pregnancy and parenting responsibilities pose one of the greatest barriers to scholastic advancement and achievement. Research also confirmed pregnancy and parenting responsibilities were significant factors for many girls to drop out of school. However, this alone was not the sole reason for the differences between Hispanic girls and other girls. Hispanic females also confronted gender stereotyping and outright discrimination undermining their self-confidence and causing them to lower their expectations for the future, heightening the risks they will drop out of school (NWLC & MALDEF, 2008).

Students’ learning behaviors have been directly related to science achievement, based upon the notion students will not learn if they do not spend time studying the subject (Peng, Wright, & Hill, 1995). Studies also have found African American and Hispanic students suffered from a lack of persistent effort as well as poor involvement in classroom participation. For example, African American and Hispanic students were more likely to fail to complete homework assignments, perform below their ability, and
be inattentive in class. Students engaging in negative learning behaviors representing a lack of persistent effort and active involvement scored lower on science and mathematics achievement tests (Peng et al., 1995).

Lack of self-confidence has been found to affect minority female students. Hernandez (1995) conducted a study to examine if role models influenced the self-efficacy and aspirations of Mexican-American at-risk females. The consistent findings suggested most of the girls in the study (88 percent) struggled with lack of self-confidence associated with fear of the unknown. Some of their remarks included the need for detailed information about academic or other requirements for their chosen career, for clear parameters respective to the roles and functions of those careers, and a clear path for what to do in the case of setbacks, failures, or errors.

In summary, research on minority middle school girls in the science domain, which can have a significant effect on students’ future careers, are few. Therefore, studies in self-beliefs, attitudes, and interests in science for minority girls would not only add to the pool of research, but help science educators in their efforts to support these girls’ performance.

**Theoretical Framework**

The research hypotheses for this study are centered on a combination of two theoretical foundations, social cognitive theory (Bandura, 1986) and cultural-ecological theory (Ogbu, 1981) and were formulated to build upon earlier research results related to self-efficacy, attitudes, interests, and performance in science in educational settings.

**Social cognitive learning perspective.** According to Bandura (1991), social cognitive theory (SCT) is rooted in a view of the human self, in which individuals are
agents actively engaged in their own cognitive development and can make things happen depending on their actions. A critical contribution to this sense of self is the fact that, among other personal factors, individuals possess self-convictions enabling them to exercise a measure of control over their thoughts, feelings, and actions. Bandura writes "what people think, believe, and feel affects how they behave" (p. 25). As a result, individuals are viewed both as products and as producers of their own environments and of their social systems. Because human lives are not lived in isolation, Bandura expanded the concept of human agency, the capacity for human beings to make choices, to include collective agency. People work together on shared beliefs about their capabilities and common aspirations to better their lives.

One of the main dependent constructs of Social Cognitive Theory (SCT) is human learning. SCT provides a framework for understanding, predicting, and changing human behavior. The theory identifies human behavior as an interaction of personal factors, behavior, and the environment (Bandura 1977; Bandura1986). According to Jones (1989), “the fact that behavior varies from situation to situation may not necessarily mean that behavior is controlled by situations, but rather that the individual is interpreting the situations differently and thus the same set of stimuli may provoke different responses from different people or from the same person at different times” (p. 23). Therefore, social cognitive theory is helpful for understanding and predicting both individual and group behavior and identifying methods in which behavior can be modified or changed.

**Self-efficacy.**

Self-efficacy is the central concept in Bandura's (1986) social cognitive theory,
which he defined as an individual’s judgment of his or her capabilities to produce designated levels of performance. In other words, it is a person’s belief in his or her own capability to successfully perform a particular task. Heslin and Klehe (2006) noted that together with the goals people set; self-efficacy is one of the most powerful motivational predictors of how well a person will perform almost any undertaking. As self-efficacy is more specific and circumscribed than self-confidence (i.e., a general personality trait that relates to how confidently people feel and act in most situations) or self-esteem (i.e., the extent to which a person likes him or herself), it is generally also more readily developed than self-confidence or self-esteem.

Self-efficacy is also a much stronger predictor of how effectively people will perform a given task than either their self-confidence or their self-esteem. A high degree of self-efficacy leads people to work hard and persist in the face of setbacks, as exemplified by many great innovators and politicians who were not discouraged by repeated barriers, ridicule, and minimal encouragement (Heslin et al., 2006).

Individuals develop their self-efficacy perceptions by interpreting information from four sources, with the first and most important source of information coming from the interpreted results of one's past performance (Bandura, 1986, 1997). He noted authentic mastery of a given task can create a strong sense of effectiveness to accomplish similar tasks in the future.

Alternatively, he stated, that repeated failure can lower efficacy perceptions, especially, when such failures have occurred early in the course of events and could not be attributed to lack of effort or external circumstances. Bandura (1986, 1997) stressed
continued success, on the other hand, can create hardy efficacy beliefs occasional failures will unlikely undermine.

The second source of self-efficacy, Bandura (1986, 1997) added, is gained vicariously through the experience one undergoes when observing others performing tasks. He noted by observing the successes and failures of other individuals, perceived as similar in capability to one contributes to one’s beliefs in one’s own capabilities. The behavior of role models is particularly influential. In situations where individuals have had little experience from which to form a judgment of their capabilities in a particular area, role models can be especially helpful (Bandura, 1986).

Bandura (1997) pointed out beliefs of personal proficiency are also shaped by the verbal persuasions one receives. This constituted the third source of self-efficacy. Verbal messages and social encouragement helped individuals to exercise extra effort and to maintain the persistence required to succeed, which ultimately resulted in the ongoing growth of aptitudes and of self-efficacy. Verbal persuasion has been shown to exert the greatest effect on people who already believe themselves capable of accomplishing a particular activity.

Individuals look to their physical and emotional states as a fourth source of information about their capabilities. Stress and tension are often interpreted as indicators of susceptibility to failure, and one's mood can have a pronounced effect on self-efficacy beliefs. Typically, optimism and a positive mood enhance efficacy beliefs, whereas depression, despair, or a sense of despondency diminishes those (Zeldin & Pajares, 2000).
Using a self-efficacy model as a framework has been reported to help understand the choice in college majors among high school girls who expressed interests in science and engineering (Nauta & Epperson, 2003). Often enough, women aptly competent in science and mathematics failed to pursue a career in these fields because they had low self-efficacy perceptions about their capabilities. On the other hand, students with strong self-efficacy were motivated to perform by setting higher performance goals, exerted more efforts to reach these goals, and were more resilient when difficulties arose (Bandura, 1997). Therefore, students with high science, technology, engineering, and mathematics (STEM) self-efficacy typically performed better and persisted longer in STEM disciplines than those with relatively lower STEM self-efficacy (Pajares, 2005; Britner et al., 2006). Additionally, it has been shown self-efficacy can be used to predict academic performance beyond the individual’s ability or previous achievement (Bandura, 1997).

Bandura (2005) argues the higher the students’ perceived efficacy to fulfill educational requirements and occupational roles, the wider the career options they seriously consider pursuing, the greater interests they have in them, the better they prepare themselves educationally for different occupational careers, and the greater their staying power in challenging career pursuits. People with lower self-efficacy simply eliminate from consideration occupations they believe to be beyond their capabilities, however attractive the occupations may be.

The topic of self-efficacy has received extensive attention and support as it relates to career development, as well as academic and career decision-making among women and students of color (Byars & Hackett, 1998; Flores & O'Brien, 2002; Gainor & Lent,
1998; Schaefers, Epperson, & Nauta, 1997; Tang, Follad, & Smith, 1999). One study indicated, after ability, math and science self-efficacy accounted for the largest significant contribution to identifying male and female college students who continued to pursue engineering as a major (Schaefers et al., 1997). Only recently has research begun to examine the self-efficacy of career women of color (Hackett & Byars, 1996; Byars et al., 1998). Because of the influence of both racism and sexism on the socialization experiences of women of color and the potential impact of oppression on the sources of efficacy information, this is an important focus of study. Although there has been speculation about the likely influences of divergent socialization experiences on the career self-efficacy of women from various cultural backgrounds (Byars et al., 1998; Suarez-McCrink, 2002), little empirical evidence is currently available. The information that does exist, however, suggests self-efficacy may be a particularly potent variable in the vocational behavior of women of color.

In review, the body of research accumulated since 1981 strongly suggests women’s tendency to exhibit lower self-efficacy for a variety of career-related variables that served as a significant cognitive barrier to career development (Betz, 2000). As such, an important component of women’s career counseling must include the assessment of career-related self-efficacy beliefs and then the implementation of interventions designed to increase self-efficacy in targeted domains, thereby expanding the range of career options (Betz & Hackett, 1997).

Bandura’s self-efficacy framework does not entirely explain the low science achievement and STEM fields’ under participation of Hispanic females. A more comprehensive understanding of the factors responsible for this underrepresentation can
be attained when Bandura’s self-efficacy framework is complemented with Ogbu’s (1981) cultural-ecological lens.

**Cultural ecological perspective.** Ogbu (1981, 1983) cultural-ecological theory, even though, controversial has had enormous influence on anthropological education. In order to provide more objective and wholesome analysis of the development of the URM female student’s school and, therefore, science perceptions, Ogbu (1981) offered a different perspective that is a cultural-ecological point of view. He developed a model for cross-cultural research which has been shown to be particularly useful when studying minority immigrant children in the U.S. It is based on the development of specific “competencies,” skills, or abilities essential for managing and coping with the existing realities.

Ogbu’s cultural-ecological perspective, allows for the cross-cultural study of the development of human competencies for school success (1981) and the study of minority student performance. He proposed academic success is not solely determined by early socialization experiences determined by child-rearing backgrounds and individuals from disadvantageous upbringings are able to learn well in the same schools by acquiring required competencies or skills at different points in their lives. That is, one does not have to experience a Caucasian middle-class upbringing or receive supplemental early childhood interventions to become a successful professional later in life. This development of human competencies also depends on institutionalized patterns of behavior interdependent with features of the environment (Ogbu, 1991, p. 122).

It is important to understand Ogbu’s cultural-ecological perspective includes the fact that in a specific population, the development of human competencies is
characterized by what is culturally defined as adult tasks. The attainments of these specific tasks are necessary to become competent men or women in that specific society (Ogbu, 1981). When a culturally different group finds itself in a different environment, such as minority students amid a dominant cultural group, the members of this minority group would respond differently from the others to their environment’s demands. Such responses could be explained because the minority group is used to dealing with different environmental resources and because they have a different history of resource utilization. Therefore, the expectation a minority group would respond in the same fashion as the dominant cultural group to a specific environmental demand without taking into account the cultural-ecological point of view, would be inequitable.

Another aspect of Ogbu’s theory was the idea that, in order to understand the academic performance of minority student, it was necessary to distinguish between, what he called; voluntary and involuntary minorities (1983, p. 168). “Voluntary minorities” are those who immigrated voluntarily to a host country said to have an active and focused approach to their host country culture and its institutions. While, “involuntary minorities” are those whose minority position is the results of historic subjugation after conquest or forced migration and are said to have an oppositional approach to their host country main culture and its institutions. According to Ogbu, each type of minority has developed different approaches to schooling.

Another pillar of Ogbu’s (1987) theory contended community and system forces impacted academic success. He reached the conclusion minority student’ lower academic achievement was a type of a “survival” adaptation strategy to the structural aspects of society and schooling, which hindered minority academic successes. A drawback of
Ogbu’s theory, however, is the fact there is little room for the explanation of the existence of involuntary minority high-achievers whose motivation to strive and succeed are rooted in their experiences as community participants (Foster, 2004).

In conclusion, bearing in mind academic achievement is not only an individual, but also a societal- collective problem in need of societal-collective solutions, Ogbu’s cultural-ecological point of view complemented by Bandura cognitive theory of learning framework offer some consistent considerations to understand the roots of the Hispanic female students’ academic performance in science.

**Conceptual Framework.**

The present study adopted a conceptual framework based on the reciprocal relationship existing among various factors of an external and internal nature in molding an individual’s self-beliefs. Understanding how this relationship can influence the development of student academic performance and choice of professional career path is one step toward increasing the engagement of Hispanic female students in STEM. External factors related to family, culture, socio-economic level, and school environment; as well as, the intrinsic or personal characteristics of the individual can be sources of strength or vulnerability in shaping a student’s academic outlook. Consequently, the development of characteristics, which have been reported to foster academic success and resilience in students, self-efficacy, positive attitudes, and interests may well increase the representation of Hispanic females in STEM careers.

There is indication students’ interests and attitudes towards science affect their academic achievement (Häussler & Hoffmann, 2000; Schibeci & Riley, 1986), as well as their course and career choices (Dawson, 2000). Young women especially become
disinterested in a science career because of the commonly held belief of the stereotypical “super-woman” role, a role that seems to require balancing a science career and family life, the total commitment required to be a scientist, and the extreme competitiveness for the pursuit of excellence in science (Gilbert et al., 2003). Such an environment is not naturally hospitable for women, who apparently prefer an environment of cooperation rather than competition. Therefore, having a family and a scientific career are incompatible undertakings for some minority female students (Christidou, 2011).

**Perceived self-efficacy in science.**

Self-efficacy serves as a mediator between a student's abilities and subsequent academic performance in that she will avoid those academic tasks in which she lacks confidence and chooses those careers in which she feels she will succeed (Schunk, 1985). When encountering difficulties with a task, students with strong self-efficacy will exercise more effort and persist longer than those with low self-efficacy. These differing levels of choice, effort, and persistence can facilitate results that then serve to strengthen the positive or negative self-efficacy beliefs of a student.

The field of mathematics has pioneered the use of self-efficacy as a tool in academic contexts. Not only does mathematics self-efficacy predict performance in this domain among students in college, high school, and middle school (Graham, 2000; Pajares, 1996; Pajares & Graham, 1999; Pajares & Kranzler, 1995; Pajares & Miller, 1995), but it also predicts mental ability (Pajares et al., 1995).

In a three-year longitudinal study of middle school students, mathematics self-efficacy predicted end-of-year mathematics performance in grades 6 through 8 for both gifted and regular education students (Graham, 2000). Self-efficacy in mathematics
research has substantiated Bandura’s argument about self-efficacy being the strongest forecaster and intermediary of achievement across academic levels (Hackett, 1985; Pajares et. al., 1999; Pajares & Johnson, 1994; Pajares & Valiante, 1997; Shell, Murphy, & Bruning, 1989). Britner (2002) contended self-efficacy is domain and task specific and this self-efficacy can exert a long-term influence on the lives of middle school students. In science for example, students’ confidence in their abilities usually affects future course-taking patterns that may in turn open or close future career options in science or technology.

Attitudes toward science.

Fishbein and Ajzen (1975) contended “attitude can be described as a learned predisposition to respond in a consistently favorable or unfavorable manner toward an attitude object" (p. 6). Attitude is an attribute an individual learns either actively or by vicarious experiences and is susceptible to change. It is important to note the changeable nature of an attitude is tied to its specificity (Wrightsman, 1977). The object to which the attitude is directed can be a person, situation, group, policy, issue, or an abstract idea. There is evidence, even though attitudes are subject to change, such events do not occur randomly and a specific event has to happen to trigger the change (Koballa, 1988).

In recent years, science education has given attention to attitude research because of a suggested relationship between attitude toward science and other attributes such as student science-related behavior. As suggested by Fishbein et al., (1975), students are not born liking or disliking the study of science in school; they learn to like or dislike it.

Singh et al. (2002) argued mathematics and science achievement among eighth graders in their study was mainly influenced by motivation, attitudes, and academic
engagement. These results were encouraging because these variables are susceptible to change. Educators have the opportunity to alter negative attitudes and strengthen more positive ones toward mathematics and science by promoting better classroom practices and providing positive experiences in these domains.

It has been argued the chronic underrepresentation of women and minorities in science fields results partly from negative science-related attitudes and from low perceived self-efficacy beliefs (Smist & Owen, 1994). Likewise, Hill, Tettus, and Hedin (1990) suggested attitudes toward science are regularly correlated with course selection and career choice.

**Interests in science.**

There is a reciprocal and positive relationship between self-efficacy and academic interests and engagement. A student’s high sense of science self-efficacy stimulates active engagement or interests and subsequent performance on a specific task. Successful performance on such tasks causes greater interests and future undertaking of more challenging activities (Schunk & Pajares, 2002). Interests has been reported to be more closely related to self-efficacy than to actual ability (Bandura, 1991). That is, many girls and young women are reported to lose interests in science regardless of their abilities. They do not believe in their capacity to attain their science goals, which leads to their diminishing interests in completing a degree (Eccles, 1994; Seymour et al., 1997).

Häussler et al. (2000) suggested students’ interests in science involves three dimensions; a) interests in a particular context in studying science, b) interests in a particular content connected with that context, and c) interests in a particular activity a
student is engaged in, in conjunction with that content. As a result, the context in which science is studied is a powerful predictor of students’ interests.

Zeldin et al. (2000) indicated the most influential sources of self-efficacy, attitudes, and interests toward science for girls and women are vicarious experiences and social persuasion. Therefore, role models are especially influential mainly when they are perceived as similar to the observer, thus suggesting that interaction with female teachers or female science professionals could positively influence female science students.

Performance in Science.

Science self-efficacy has been reported to predict academic performance because previous achievements motivate the individual to succeed. Zimmerman (2000) and Pajares (2005) argued students with high science self-efficacy expend greater effort and persist longer at completing a specific activity in spite of adversity. As a result, science self-efficacy is positively related to science task performance. Bandura (1997) contended there is a reciprocal and continuing relationship between self-efficacy and performance. That is, successful task performance enhances self-efficacy, leading to undertaking more difficult and challenging jobs.

The middle school years are, then a critical period for American students regarding achievement in mathematics and science. Their performance in these subjects in middle school determines high school choices in enrolment in higher-level mathematics and science courses. Similarly, early interests and positive attitudes toward mathematics and science have been related to educational and career aspirations in these disciplines (Singh et al., 2002).
In summary, this study used the literature on science and mathematics, girls in science, school success, and factors which can possibly influence student perception of science, to seek answers to the following research questions:

1. To what extent do attitudes and interests toward science differ among adolescent middle School, female students of diverse ethnic/racial backgrounds —African American, Asian/Filipino, Hispanic, and Caucasian?

2. What are the correlation levels between favorable attitudes and interests toward science and academic achievement of middle school female students after controlling for other external factors such as parental education level and home language?

3. In what ways do external factors have an effect on Hispanic middle school female students’ perceptions of their self-efficacy, attitudes, and interests and personal aspirations of pursuing a career in science?
CHAPTER THREE: METHODOLOGY

This study explored whether attitudes and interests toward science differ as a function of ethnic/racial background and academic achievement in middle school female students when other variables, which have been found to influence achievement in science, are controlled. In addition, the study explored the effects of external factors, such as vicarious and encouragement experiences in the life of Hispanic middle school female students, to better understand the role of these factors in shaping student perceived self-efficacy in science and personal aspirations to pursuing a career in science. The results from this study will inform teachers, school officials, and parents about interventions that could positively impact science learning environments for minority females in middle school.

In this chapter, I first restate the research significance, research questions, and hypotheses as they inform the methodology chosen to study the problem. Second, I describe the study's participants and selected schools. Third, I explain the research design procedures involved in data collection, describe the scales used in the instrumentation of the research questions, and outline the statistical analyses performed.

Significance of the Study

The analysis of minority female student attitudes, interests, and perceived self-efficacy in the science domain is important to study for several reasons:

1. The study can inform school leaders and teachers about their female students’ levels of positive attitudes and interests toward science, which could assist them in developing specific pedagogical practices in their classes to increase student perception and enjoyment of this domain.
2. Identify effective practices in families, society, and school environments, which foster science self-efficacy in minority female middle school girls to increase their participation in STEM disciplines.

3. Assist and support parental involvement in the development of a robust self-Efficacy in science for their daughters by informing them about the most efficacious practices which contribute to the development of successful self-efficacy in science abilities.

Research Questions

This investigation will attempt to answer the following research questions:

1. To what extent do attitudes and interests toward science differ among adolescent middle school, female students of diverse ethnic/racial backgrounds —African American, Asian/Filipino, Hispanic, and Caucasian?

2. What are the correlation levels between favorable attitudes and interests toward science and academic achievement of middle school female students after controlling for other external factors such as parental education level and home language?

3. In what ways do external factors have an effect on Hispanic middle school female students’ perceptions of their self-efficacy, attitudes, and interests and personal aspirations of pursuing a career in science?

Research Hypotheses

The research hypotheses for this study are centered on a combination of two theoretical foundations, social cognitive theory (Bandura, 1986) and cultural-ecological theory (Ogbu, 1981). These hypotheses were formulated to build upon earlier research
results related to self-efficacy, interests, and performance in science in educational settings. The research hypotheses were as follows:

1. The ethnic/racial background of middle school students will contribute to the positive levels of attitudes and interests toward science.

2. Mean scores in levels of positive attitudes and interests toward science of middle-school girls will not significantly differ among middle school female students based on performance.

3. Perceived self-efficacy and aspirations of Hispanic middle-school female students for pursuing a science career will be influenced by external factors such as verbal persuasions and vicarious modeling.

**Research Design**

**Participants and setting.** The population in this study was seventh grade female students of diverse ethnic/racial background who were taking a science course in one of two middle schools in different school districts in Southern California. The schools will be referred to here as Valley Middle School and Hill Middle School. The two schools were purposefully chosen based on the ethnic/racial student population they served as reported on their Web sites. This school selection process was done with the aim of capturing the typical population composition in Southern California. Valley Middle school serves a student population of 39 percent Filipino, 36 percent Hispanic, 19 percent African American, and 5.5 percent Caucasian and Hill Middle School serves a student population of 47 percent Hispanic, 30 percent Caucasian, 7 percent Asian, 7 percent African American, and 8 percent other.
A purposeful sampling of the students from four teachers who volunteered to participate determined the participants for the study.

**Comprehensive study design.** This study uses sequential explanatory mixed methods design (Newman & DeMarco, 2003). This type of study is characterized by the collection and analysis of quantitative data followed by the collection and analysis of qualitative data. Priority is typically given to the quantitative data, and the two methods are integrated during the interpretation phase of the study.

Figure 1 illustrates the study sequential explanatory mixed methods design. The purpose of the sequential explanatory design typically uses qualitative results to assist in explaining and interpreting the findings of a primarily quantitative study. The quantitative results can then be used to guide the purposeful sampling of participants for a qualitative study.

The quantitative initial phase of the study was based on the association between attitudes and interests toward science and a measure of student science academic achievement studied through survey research methods administered to 284 seventh grade female students. The sequential second phase of the study was qualitative using semi-structured personal interview design with 18 Hispanic seventh grade females from high and low academic achievement range in science.

This phase gathered in depth information about this ethnic group of students’ external and internal sources of self-efficacy toward science that could explain their attitudes and interests in science.
Comprehensive study assessment, instrumentation, and data collection. The study was conducted in two consecutive phases. Phase 1 utilized quantitative methods and consisted of a survey followed by phase 2 the qualitative phase consisting of semi-structured face-to-face personal interviews.

**Phase 1: Quantitative phase (survey).**

**Instrumentation.** To assess student positive attitudes and interests toward science, a survey was administered at the end of the spring semester of the seventh grade academic school year. The Test of Science Related Attitudes (TOSRA, see appendix B) survey (Fraser, 1981) was piloted at a middle-school prior to administering it to the participating students. The pilot study helped to assess if the complete survey (70 Likert-items) was significant to the purpose of this study. After analysis of the pilot study results, it was decided the complete survey was the most pertinent survey form for this
research study.

The Test of Science-Related Attitudes is an instrument consisting of seven attitude sub-scales, each having ten Likert-type items or statements. Supported by Klopfer's (1971) rationale of science attitude, the seven subscales have been called: Social implications of science, Normality of scientists, Attitude of science inquiry, Adoption of scientific attitudes, Enjoyment of science lessons, Leisure interests in science, and Career interests in science. In the TOSRA, The Social Implications of Science subscale measures the “manifestation of favorable attitudes towards science” (Fraser, 1981, p. 2). This survey includes attitude towards the social benefits and problems associated with scientific progress and research.

The Normality of Scientists subscale measures the attitude toward scientists as normal people rather than eccentrics. This scale measures how students perceive scientists as individuals and their perceptions of scientists as having a normal lifestyle.

The Attitude of Scientific Inquiry subscale measures attitude toward scientific experimentation and inquiry as methods of obtaining information about the natural world. This subscale measures the acceptance of scientific inquiry as a way of thought. Fraser maintained Klopfer’s classification based on the following

“…if a student accepts the processes of scientific inquiry as a valid Way to conduct his thinking, his behavior in approaching a problem or novel situation will be sufficiently consistent for competent observers of his action to describe him as behaving just like a scientist” (Klopfer, 1971, p. 577).

The Adoption of Scientific Attitudes subscale measures open-mindedness, willingness to reverse opinions related to scientific investigation and inquiry. This scale measures the how likely students are to change their way of seeing the world based on
scientific evidence. The Enjoyment of Science Lessons Likert-scale measures the enjoyment of science learning experiences. This includes participating in science labs as well as attending science classes. According to Klopfer (1971),

…the sight, sound, and smell of phenomena; the uncovering of a new relationship, generalization, or explanation the spark of discussions of Conflicting ideas – these are all potential sources of involvement and enjoyment” (p. 578).

The Leisure Interests in Science subscale measures the development of interests in science and science-related activities. Fraser’s category is designed to reflect the students’ interests in hobbies and extra-curricular activities outside of classroom related to science. Lastly, the Career Interests in science sub-scale measures student interests in pursuing a science career after she finishes school.

TORSA has been tested in a number of public and private schools in Australia. Tested in two American Catholic schools, the data were similar to Australian data, suggesting the scales have cross-cultural validity (Fraser, 1981). The statements on the scales are moderately negative or positive, a requirement for Likert-items and balance for negative and positive statements on each of the seven scales, a practice that helps to curb a response set phenomenon on the part of respondents. The sentence structure of the negative statements helped to eliminate potential language difficulties associated with double negative, especially challenging for Spanish speaking natives instead of using "not" in each negative statement, the author has incorporated such words as "dislike," "uninteresting," "unimportant," and "bored."

*Academic Achievement.* Academic achievement in science was measured by
using the end of the school year students Grade Point Average (GPA). The student grade point average (GPA) in science was used as an independent variable, in order include a measure or indicator of student academic performance, to triangulate student perceived self-efficacy in science and student attitudes and interests or engagement in science class. Student science performance data was collected from school records at the end of the school year.

Permission from the students’ parents was ensured prior to obtaining this information (Parental consent and students’ assent permission form, Appendix A). Student anonymity was ensured during the collection of survey assessments and student GPA by using student identifications number instead of their names. All statistical tests were performed based on guidelines published by Pallant (2010) SPSS survival manual and using the IBM SPSS 20.0 statistical software.

**Phase 1 procedure.** Written permissions to conduct the investigation were obtained prior to beginning the research for each of the participating middle-schools as well as for the California State University San Marcos Institutional Review Board (IRB). Written permissions were obtained from parents of participating students (see Appendix A).

The researcher was the sole administrator of both the survey and the interview. Procedures to administer the survey were consistent with those provided by the author of the TOSRA survey instrument (Fraser, 1981). The survey was group administered during the participants’ science class during the Spring semester of the academic year 2011-2012. Students were told the purpose of the study was to obtain their opinions about science and about themselves as science students. They were informed the results of the
survey were confidential and would not affect their science grade. Before taking the
survey an explanation of how to take the Likert-type scales was given and the students
were guided through the first item to ensure their understanding.

Students were told they could stop at any time if they so desired. Students also
were encouraged to ask questions at any time during the survey. This encouragement
was done to minimize students’ uncertainty about questions on the scale and to reduce the
likelihood of their leaving a question unanswered. No problems during the
Administration were reported and none of the students chose to stop the survey during
administration.

Students had five choices of response: (a) strongly agree, (b) agree, (c) not sure,
(d) disagree, and (e) strongly disagree. Although no time limit is imposed for
administration of the scale, the original authors suggest younger students be expected to
complete the scale in 30-45 min; while older students might require only 25-30 min
(Fraser, 1981). This procedure sacrifices validity for expediency; therefore, it was
recommended the slow child be given time needed to respond.

**Phase 2: qualitative phase: Hispanic female student personal semi-structured
interviews.**

**Phenomenological study.** To enrich the understanding of the statistical survey
analyses, qualitative data were collected from 18 Hispanic female science students. The
data were collected in the form of face-to-face semi-structured personal interviews
(Creswell, 1998). The interviews were audio-taped, transcribed, and analyzed by the
researcher.

The purpose of qualitative research interviews, as explained by Kvale and
Brinkmann (2009), is to understand issues from the students’ perspective of their daily world. Therefore, I selected qualitative methods to gather rich accounts and descriptions of the sources of self-efficacy Hispanic student experienced through their natural everyday stories. Researchers suggest quantitative analysis in the study of self-efficacy should be complemented by qualitative efforts to investigate how perceived self-efficacy beliefs are acquired (Pajares, 1996; Schunk, 1991). This approach allowed the researcher to understand how students perceived their beliefs influenced their academic achievements and the academic roads they follow.

In the present study, the case of high and low science performing Hispanic female students is significant because in uncovering their sources for, or lack thereof, self-efficacy important directions in science education could be provided thereby increasing their participation in science fields.

Interview participants. Participants were 18 Hispanic female students enrolled in science classes at two participating middle schools. Participants in this phase were also participants in the quantitative or survey phase of the study. The decision to include only students of Hispanic background in the interview phase of the study was based on reports that female of Hispanic background are the most underrepresented minority in science when their numbers in the total population is taken into account (NSF, 2009). With this information in mind, it was decided that by gathering the data of this student group’s personal experiences in science, it would provide depth and richness to the study and maybe shed light on the possible reasons for their underrepresentation in the different science fields.

The Hispanic female students were selected by their science teachers on the bases
of their class performance during the school academic year. Teachers referred students for participation in the interviews from the high and the low academic achievement range in their science class. Parental permission was secured prior conducting the interviews (see, Parental consent, and student assent to participate in an interview forms, Appendix A).

**Instrumentation, procedure, and data collection.** The qualitative phase involved an open-ended, semi-structured personal interview in which each participant was asked the same questions in a similar order focused on the four different sources of self-efficacy as follows: family, school, peers, and community.

The purpose of the interview was to explore and determine the following six factors:

1. the student interests in science class and related activities,
2. the extent of, or lack thereof, family encouragement,
3. the extent of school or teachers influence or encouragement,
4. the influence of peers and friends,
5. the influence of community, and
6. the student feelings or recommendations for increasing their interests in science class.

The researcher alone conducted, recorded, and transcribed the interviews.

**Comprehensive study data analysis.** The data analysis is presented in the order in which the data was collected.

**Phase 1: quantitative analyses.**

*Test of science related attitudes survey.* Using SPSS computer program, the
reliability of the internal consistency (the extent to which items in a given scale measure the same attitude) of each of the TOSRA subscales produced an estimated Cronbach coefficient at 0.82 (Cronbach, 1951). In addition, the reliability of the internal consistency, among subscales, for the data collected in this study was calculated at a Cronbach coefficient 0.89. These coefficients showed quite good internal consistency among subscales at each level and substantial agreement with previously reported studies (Fraser, 1981).

Intercorrelations among TOSRA subscales were calculated as indices of discriminant validity (the extent to which a given scale measures a unique attitude not measured by other scales in the battery). The data for this study data for a total sample of 284 showed that TOSRA subscale intercorrelations were generally fairly low and ranged from 0.22 to 0.81 with a mean of 0.51. It is noteworthy to mention the highest scale intercorrelations (values of 0.67, 0.78, and 0.81) occurred as reported by Fraser (1981) between the three scales of Enjoyment of Science Lessons, Leisure Interests in Science and Career Interests in Science. Although these three attitudes are conceptually distinct, one would generally expect them to be moderately well correlated among students since there would be a tendency for a student who enjoys science lessons to be more likely to have a leisure and career interests in science.

The means, standard deviations, minimum, and maximum values, ranges, Skewness, and Kurtosis of the TOSRA seven subscales, categorical variable, are shown in Table 4.1 next page.

*Student demographic data.* All the student demographic data — Student ethnicity/racial background, Academic achievement, Parent education level, and Home
language — was entered into the SPSS software program and descriptive statistical analysis were performed.

Table 4.1: Descriptive statistics for each of the TOSRA seven Subscales

<table>
<thead>
<tr>
<th>TOSRA</th>
<th>N</th>
<th>Range</th>
<th>Min</th>
<th>Max</th>
<th>Mean</th>
<th>Std. Deviation</th>
<th>Skewness</th>
<th>Kurtosis</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Statistic</td>
<td>Statistic</td>
<td>Statistic</td>
<td>Statistic</td>
<td>Statistic</td>
<td>Statistic</td>
<td>Std. Error</td>
<td>Std. Error</td>
</tr>
<tr>
<td>1</td>
<td>284</td>
<td>40</td>
<td>10</td>
<td>50</td>
<td>26.20</td>
<td>8.733</td>
<td>.206</td>
<td>-.355</td>
</tr>
<tr>
<td>2</td>
<td>284</td>
<td>40</td>
<td>10</td>
<td>50</td>
<td>28.84</td>
<td>8.650</td>
<td>.018</td>
<td>-.389</td>
</tr>
<tr>
<td>3</td>
<td>284</td>
<td>40</td>
<td>10</td>
<td>50</td>
<td>31.64</td>
<td>9.474</td>
<td>-.136</td>
<td>-.577</td>
</tr>
<tr>
<td>4</td>
<td>284</td>
<td>27</td>
<td>21</td>
<td>48</td>
<td>34.42</td>
<td>5.049</td>
<td>.288</td>
<td>.145</td>
</tr>
<tr>
<td>5</td>
<td>283</td>
<td>35</td>
<td>14</td>
<td>49</td>
<td>34.51</td>
<td>5.877</td>
<td>-.321</td>
<td>.145</td>
</tr>
<tr>
<td>6</td>
<td>284</td>
<td>38</td>
<td>12</td>
<td>50</td>
<td>34.76</td>
<td>6.068</td>
<td>-.254</td>
<td>.145</td>
</tr>
<tr>
<td>7</td>
<td>284</td>
<td>40</td>
<td>10</td>
<td>50</td>
<td>36.10</td>
<td>7.388</td>
<td>-.282</td>
<td>.145</td>
</tr>
<tr>
<td>Valid N (list wise)</td>
<td>283</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>


The frequency and percentages of the discrete, nominal variables — ethnicity/race, home language (see tables 4.2 and 4.4 in page 55), and the means and the standard deviations for the ordinal variables — GPA, parent education level (see table 4.3 and 4.5 pages 63 and 66) — were calculated.
### Table 4.2: Student ethnic/racial background frequencies.

<table>
<thead>
<tr>
<th>Ethnicity/Race</th>
<th>Frequency</th>
<th>Percent</th>
<th>Valid Percent</th>
<th>Cumulative Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>African-American</td>
<td>34</td>
<td>12.0</td>
<td>12.0</td>
<td>12.0</td>
</tr>
<tr>
<td>Native-American</td>
<td>6</td>
<td>2.1</td>
<td>2.1</td>
<td>14.1</td>
</tr>
<tr>
<td>Asian/ Filipino</td>
<td>48</td>
<td>16.9</td>
<td>16.9</td>
<td>31.0</td>
</tr>
<tr>
<td>Hispanic</td>
<td>110</td>
<td>38.7</td>
<td>38.7</td>
<td>69.7</td>
</tr>
<tr>
<td>Caucasian</td>
<td>33</td>
<td>11.6</td>
<td>11.6</td>
<td>81.3</td>
</tr>
<tr>
<td>Other</td>
<td>22</td>
<td>7.7</td>
<td>7.7</td>
<td>89.1</td>
</tr>
<tr>
<td>Mixed Ethnicity</td>
<td>31</td>
<td>10.9</td>
<td>10.9</td>
<td>100.0</td>
</tr>
<tr>
<td>Total</td>
<td>284</td>
<td>100.0</td>
<td>100.0</td>
<td></td>
</tr>
</tbody>
</table>

*Note:* Mixed ethnicity consisted of students reporting 3 or more ethnic/racial background and other ethnicities consisted of students reporting different ethnic background with less than .5 % frequency.

### Table 4.4: Student Home Language Distribution.

<table>
<thead>
<tr>
<th>Language</th>
<th>Frequency</th>
<th>Percent</th>
<th>Valid Percent</th>
<th>Cumulative Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>English</td>
<td>152</td>
<td>53.5</td>
<td>53.5</td>
<td>53.5</td>
</tr>
<tr>
<td>Spanish</td>
<td>44</td>
<td>15.5</td>
<td>15.5</td>
<td>69.0</td>
</tr>
<tr>
<td>Tagalog</td>
<td>15</td>
<td>5.3</td>
<td>5.3</td>
<td>74.3</td>
</tr>
<tr>
<td>Dual Language</td>
<td>54</td>
<td>19.0</td>
<td>19.0</td>
<td>93.3</td>
</tr>
<tr>
<td>other</td>
<td>19</td>
<td>6.7</td>
<td>6.7</td>
<td>100.0</td>
</tr>
<tr>
<td>Total</td>
<td>284</td>
<td>100.0</td>
<td>100.0</td>
<td></td>
</tr>
</tbody>
</table>
Assessing Normality of the Data. To assess the normality of the distribution of the seven TOSRA subscale scores, the results of the Kolmogorov-Smirnov Normality test were analyzed. The results showed all the seven TOSRA subscales, with the exception of Enjoyment of Science Lessons, showed a statistically significant value, $p < .05$. Even though, this $p$ value suggested a violation of the assumption of normality, which is quite common in large samples (Pallant, 2010). The Histograms of the scores showed to be reasonably normally distributed in a bell-shape and the Normal Q-Q plot of the seven subscales showed scores in straight lines suggesting normal distributions.

Assessing for possible correlations among ethnicity, attitudes, and interests toward science. To explore if any correlation effect existed between student ethnicity and their attitudes and interests toward science (as measured by their scores on the seven TOSRA subscales), the non-parametric between- groups Kruskal-Wallis H statistical test (Pallant, 2010) was performed (See table 4.5 on pages 65 for results). This test allowed for the comparison of scores on the continuous variable (TOSRA subscale scores) for several groups in the independent categorical variable — student ethnicities (Pallant, 2010). This analysis was relevant to answering research question number one.

Next, the TOSRA survey data was also used to find a response to this study second research question: Do student attitudes and interests toward science (as measured by the seven TOSRA subscales) varied in terms of student performance (as measured by their GPA), while controlling for the possible underlying impact of the degree of parent education.

Bivariate correlation statistical preliminary tests were used to explore any possible underlying association between the level of parental education and student performance.
(any significant confounding correlation between these two independent variables could conceal a factual relationship between student performance and their degree of positive attitudes and interests toward science). After establishing there was no statistically significant confounding effects between these two independent variables, any correlation between student academic achievement (as measured by their GPA) and student attitudes and interests in science were determined through standard partial correlation analysis.

Lastly, to explore if student academic achievement would account for the mean score variance observed on student attitudes and interests in science, a one-way between-groups analysis of variance (ANOVA) was performed. The post-hoc analysis data revealed there were specific statistically significant differences in the degree of positive attitudes and interests toward science among the three student performance groups.

**Phase 2: qualitative analyses**

Audio tapes of the semi-structured interviews were transcribed by the researcher. The interview transcriptions were manually coded using the Content Analysis technique (Kvale & Brinkmann, 2008), which uses pre-identified categories or themes to determine common emerging subthemes or concepts for interpretation and discussion. Important concept-propositions were used from each subtheme to create the narrative framework specific to the Hispanic female students’ personal and external experiences and beliefs.

The use of main categories or pre-defined ideas allow the researcher for quantification and comparison of category frequency relevant to this study research question number three were identified as subthemes within each main category or themes with the purpose of determining if they pose any relationship to the two main sources of
self-efficacy (verbal persuasion and vicarious experiences). The emergent subthemes were classified and are presented in this study on the basis of their frequency.

**Reliability and Validity.** External validity, focusing on the generalizability of the findings, is an important concern in qualitative research. Because we did not use random sampling, the analogy to statistical generalization should be avoided. I addressed validity concerns in keeping with guidelines set out by Merriam (1988). I attempted to assess and report in a detailed manner the ways in which the participants' self-efficacy beliefs played a role in their academic and career development.

**Chapter Summary**

Using a purposeful sampling, a representative group of 284 volunteer seventh grade female students consented to participate in this research study. The study was conducted in two middle schools from different school districts located in urban areas of Southern California, which reflected the mixed ethnic/racial background student composition.

This two-phase explanatory sequential, mixed methods research design used in the first phase, quantitative analyses of survey responses of 284 of diverse ethnic/racial background students. The survey data were used to explore answers to the first and second research questions. The first research question established the extent student ethnicity accounted for the variance in positive levels of attitudes and interests toward science. Non-parametric statistical tests established the statistically significant differences among student groups of different ethnicities. The data obtained for the TOSRA survey was also examined to answer the second research question — to what extent does academic performance influence student attitudes and interests toward
science, while controlling for parent education levels ?. Preliminary analysis revealed even though there was a direct small positive relationship between the degrees of parental education and student performance; it was not a statistically significant one.

Further analysis (Standard Bivariate correlation) established the sole direct relationship between student attitudes and interests toward science and subsequent performance. A one-way between-groups analysis of variance test was included to determine if student performance could account for any variance observed on their levels of positive attitudes and interests in science. Post-hoc analysis data pint pointed specific the statistically significant differences among the three student performance groups.

In the second phase, 18 Hispanic students from the high and low academic performance ranges participated in face-to-face semi-structured interviews to allow for a richer and deeper analysis and interpretation of possible external environmental influences on student self-efficacy perceptions toward science, which could have affected the extent of their positive attitudes and interests toward this domain when answering the survey.
CHAPTER FOUR: RESEARCH FINDINGS

Chapter Overview

This chapter presents the findings from the data analyses based on each research question. This research explored attitudes, interests, and perceived self-efficacy with the purpose of enriching the existing knowledge on minority female student academic achievement gap in science education.

This study was aimed at examining ways that attitudes and interests in science vary among females of different ethnic/racial background. In addition, this study investigated internal and external factors in the life of Hispanic female students, which could influence their self-efficacy in science.

A sequential explanatory mixed methods design was utilized in this research (Newman et al., 2003). This type of study is characterized by the collection and analysis of quantitative data followed by the collection and analysis of qualitative data. The purpose of a sequential explanatory design is typically to use qualitative results to assist in explaining and interpreting the findings of a primarily quantitative study. The quantitative results can then, be used to guide the purposeful sampling of participants for a qualitative study.

Data analyses and interpretation of the quantitative phase of the study will be relevant to answering research questions one and two, and the examination and interpretation of the qualitative phase will address question three.

Characteristics of the Overall Sample

The student ethnic/racial background information was obtained as part of a
three demographic question portion of the survey instrument — ethnic/racial background, parental educational level, and language spoken at home (See Appendix B for sample of demographic questions). Following completion of the demographic questions students answered the 70 questions on the TOSRA survey.

Participants were 284 seventh grade female students of diverse ethnic/racial backgrounds as follows: African American (8.5 %), Asian/Filipino (16.5 %), Caucasian (11.3 %), Hispanic (39.8 %), Native American (1.4 %), mixed ethnicity (12 %), and other ethnicity (10.6%). Refer to Table 4.2 in page 55 for the overall results.

Students which initially identified themselves as having two different ethnic/racial backgrounds were allocated to a specific minority group by following the suggestions of the NCES and Office of Management and Budget (OMB) 2000 Allocation Guidance — responses combining one minority race and white are allocated to the minority race. However, if the student identified with two ethnicities, which consisted of a combination of two minority ethnicities, the student was allocated into the mixed ethnicity. Lastly, the Others ethnic category included students having 3 or more ethnic/racial background or identifying themselves with an ethnicity other than the formerly mentioned even though the NCES (2000) suggested for postsecondary education data collection by federal agencies “…data producers are strongly encouraged to report detailed distributions, including all possible combinations, of multiple responses to the race question. If data on multiple responses are collapsed, at a minimum, the total number of respondents indicating more than one racial category must be provided” (p. 756). Very few studies reported in the literature include a mixed ethnic/racial group, which could be used as a
The language the student spoke at home more frequently was determined by offering a five-choice answer — English, Spanish, Tagalog (Official language of the Philippines), dual language, and other language than the above mentioned. The distribution of this variable revealed the language spoken at home was predominately English (53.5 %), followed by Spanish (15.5%), Tagalog (Official language of the Philippines, 5.3%), Dual language (19.0 %), and other language than the above mentioned (6.7 %). Refer to Table 4.4 page 55 for the distributions of the Home Language variable.

Students provided information about their parent educational levels. Students were provided with four-incremental levels of parental education choices, and an extra option labeled, I do not know, from where they could choose. The distribution of the degree of parent education was as follows: 26.1% two parents finished college, 24.3 % one parent finished college, 19.0% two parents finished high school, 23.6% one parent finished high school, 3.5% one or two parent finished middle school or less, and 3.5% do not know.

The Grade Point Average (GPA) variable distribution was divided into five increasing levels as reported by school authorities. These levels were as follows: A (28.2 %), B (31.3 %), C (22.9 %), and D (9.9%), and F (7.7%). The detail distribution of GPA value frequency in terms of ethnic/racial background is provided in Table 4.3 next page.

Through a one-way between- groups analysis of variance post-hoc testing, it was established there were no statistically significant differences on the degree of positive
attitudes and interests in science mean scores between the A and B achievement student groups and between the C and D student groups. Hence, the five performance student groups were clustered into three groups (Group 1: A and B, Group 2: C and D, and Group 3: F) to allow for a more clear and apparent interpretation of the possible effects of performance level on these student academic attributes.

### Comprehensive Statistical Procedures

**Research Question One.** To be able to answer research question one — To what extent do attitudes and interests toward science differ among adolescent middle school, female students of diverse ethnic/racial background.

To explore the possible effects of ethnicity on the mean variance of the seven TOSRA subscales based on ethnicity, the non-parametric between-groups Kruskal-Wallis statistical test was performed using the SPSS statistical computer program.

<table>
<thead>
<tr>
<th></th>
<th>Frequency</th>
<th>Percent</th>
<th>Valid Percent</th>
<th>Cumulative Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valid</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A</td>
<td>80</td>
<td>28.2</td>
<td>28.4</td>
<td>28.4</td>
</tr>
<tr>
<td>B</td>
<td>89</td>
<td>31.3</td>
<td>31.6</td>
<td>59.9</td>
</tr>
<tr>
<td>C</td>
<td>64</td>
<td>22.5</td>
<td>22.7</td>
<td>82.6</td>
</tr>
<tr>
<td>D</td>
<td>28</td>
<td>9.9</td>
<td>9.9</td>
<td>92.6</td>
</tr>
<tr>
<td>F</td>
<td>21</td>
<td>7.4</td>
<td>7.4</td>
<td>100.0</td>
</tr>
</tbody>
</table>
Non-parametric statistical techniques were chosen rather than parametric tests, such as ANOVA, because the survey data was measured on nominal (categorical) and ordinal (ranked) scales. This test allowed for the comparison of scores on the continuous variables (TOSRA subscale scores) for several groups in the independent categorical variable student ethnicities as suggested by Pallant (2010).

An inspection of the Kruskal-Wallis test results, indicated students of Asian/Filipino Background, conveyed statistically significant different levels of attitudes and interests toward science from the other ethnic student groups, for three of the seven TOSRA subscales, \( p < .05 \) (Enjoyment of Science Activities, Leisure Interests in Science, and Career in Science). Table 4.5 below shows the mean distribution for the TOSRA subscale scores based on student ethnicity.

**Figure 4.1:** Results of the three TOSRA subscale means in which Asian/Filipino students score the highest compared to the rest of the ethnic groups.
Figure 4.1 illustrates the results of the three TOSRA subscale means in which Asian/Filipino students score the highest compared to the other student ethnic groups.

Research question two. When addressing the second research question — What are the correlation levels of favorable attitudes and interests toward science among high and low academic achievement middle school female students after controlling for other external factors such as parental education level, and home language?

The results of the TOSRA survey were used in order to explore effects of student performance on the levels of positive attitudes and interests toward science. However, the presence of any possible confounding effects by the other independent variables (parental education degree and home language) had to be established a priori. These analyses were important because empirical studies have shown correlations exist among

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>220</td>
<td>220</td>
<td>220</td>
<td>220</td>
<td>220</td>
<td>220</td>
<td>220</td>
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<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
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<tr>
<td>p</td>
<td>.336</td>
<td>.879</td>
<td>.167</td>
<td>.672</td>
<td><strong>.007</strong></td>
<td><strong>.021</strong></td>
<td><strong>.023</strong></td>
</tr>
</tbody>
</table>

Note: The numbers represent TOSRA subscales as follows: (1) Social Implications of Science, (2) Normality of Scientists, (3) Attitudes Toward Science Inquiry, (4) Adoption of Scientific Attitudes, (5) Enjoyment of Science Lessons, (6) Leisure Interest in Science Activities, and (7) Career in Science.
performance, gender, ethnicity (Von Secker, 2004; Fry et al. 2008) to the degree of parent education (Davis-Kean, 2005).

To ascertain the existence of specific coundfunding correlations, if any, among the above mentioned independent variables and the TOSRA subscale mean scores, correlation coefficients between groups statistical analysis was performed. The results showed first, there were no statistically significant correlations between student performance and parental education, and student performance and home language. Second, there was no significant correlation between the parent education degree to each of the TOSRA subscale mean scores, third, the data analysis revealed the presence of statistically significant correlation values between student academic performance and their positive levels of attitudes and interests toward science (see Table 4.6 in page 67 for a full set of results).

The relationship between levels of parental education and student academic achievement (.176 with a $p < .005$ at the 2-tailed level). This result indicated these two variables shared only 3 percent of their variance (implied by its coefficient of determination). In addition, it was shown there was not much of an overlap effect between these two variables.

Lastly, the degree of parental education possible effect on student academic performance was analyzed by a one-way between-groups analysis of variance was conducted. The results of the one-way between-groups analysis of variance, ANOVA, suggested that even though there was a positive tendency of variance between the four levels of parental education and student achievement, none of them revealed a
The results of the Pearson correlation showed a small positive statistically significant value.

**Table 4.6:** Mean scores for the TOSRA seven Likert- scales in terms of student ethnicity.

<table>
<thead>
<tr>
<th>Ethnicity</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
</tr>
</thead>
<tbody>
<tr>
<td>African American</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>34.56</td>
<td>33.63</td>
<td>35.50</td>
<td>33.00</td>
<td>28.50</td>
<td>21.69</td>
<td>22.56</td>
</tr>
<tr>
<td>Asian/Filipino</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>35.21</td>
<td>33.28</td>
<td>35.66</td>
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<td>34.28</td>
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<td>31.34</td>
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<tr>
<td>Hispanic</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>34.02</td>
<td>34.27</td>
<td>35.24</td>
<td>34.01</td>
<td>31.21</td>
<td>26.58</td>
<td>28.71</td>
</tr>
<tr>
<td>Caucasian</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>34.78</td>
<td>34.97</td>
<td>37.06</td>
<td>33.81</td>
<td>28.25</td>
<td>21.78</td>
<td>26.34</td>
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<td>Other</td>
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<td></td>
<td></td>
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<tr>
<td>Mean</td>
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<td>34.70</td>
<td>34.90</td>
<td>35.75</td>
<td>32.75</td>
<td>28.30</td>
<td>29.20</td>
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<tr>
<td>Mixed Race</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>35.72</td>
<td>34.83</td>
<td>37.24</td>
<td>34.97</td>
<td>32.81</td>
<td>26.86</td>
<td>30.14</td>
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<tr>
<td>Total</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>34.76</td>
<td>34.42</td>
<td>36.10</td>
<td>34.51</td>
<td>31.64</td>
<td>26.20</td>
<td>28.84</td>
</tr>
<tr>
<td>Std. Deviation</td>
<td>6.068</td>
<td>5.049</td>
<td>7.388</td>
<td>5.877</td>
<td>9.474</td>
<td>8.733</td>
<td>8.650</td>
</tr>
</tbody>
</table>
Effects of Performance and Parent Education Level on student attitudes and interests in science.

Partial correlation was used to explore the relationship between levels of favorable attitudes and interests toward science (as measured by the seven TOSRA subscales) among high and low academic achievement middle school female students, while controlling for parental education levels.

Table 4.8 in page 70 shows the results of the partial correlation analyses between each of the TOSRA seven subscales and student academic achievement before and after controlling for parent education level (model 1 and model 2).

The results of these partial correlation analyses showed there were small, positive partial correlations between each of the seven subscales and performance, all with $p < .05$, when the parent education level variable was not included in this first model (Table 4.7 below). The second model, analyzed the effects of performance on student attitudes and interests in science (as measured by the seven TOSRA subscales), while controlling for parent education level.

A closer inspection of the zero order correlations ($r$, Table 4.7) for each of the TOSRA subscale values in model 1 and 2, suggested that controlling (accounting for) for parent education level had little effect on the strength of the relationship between student attitudes and interests toward science. In addition, all correlations between each TOSRA subscale value and student GPA maintained a $p$ of $< .05$ after controlling for parental education. The Pearson correlation results suggested that of the two independent variables, the degree of parental education, bore a much smaller relationship to student
attitudes and interests in science than student GPA (sig. <.05).

<table>
<thead>
<tr>
<th>Variables controlled</th>
<th>Correlation</th>
<th>Significance (2-tailed)</th>
<th>df</th>
<th>Correlation</th>
<th>Significance (2-tailed)</th>
<th>df</th>
</tr>
</thead>
<tbody>
<tr>
<td>None* Model 1</td>
<td>Correlation .277 .162 .239 .238 .277 .140 .222</td>
<td>Significance (2-tailed) .000 .006 .000 .000 .000 .018 .000</td>
<td>df 282 282 282 282 282 282 282</td>
<td>Correlation .255 .146 .219 .227 .260 .128 .205</td>
<td>Significance (2-tailed) .000 .014 .000 .000 .000 .031 .001</td>
<td>df 281 281 281 281 281 281 281</td>
</tr>
<tr>
<td>Parent Education Level Model 2</td>
<td>Correlation .255 .146 .219 .227 .260 .128 .205</td>
<td>Significance (2-tailed) .000 .014 .000 .000 .000 .031 .001</td>
<td>df 281 281 281 281 281 281 281</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: The numbers under the TOSRA subscale subtitle represent the subscales names as follow: (1) Social Implications of Science, (2) Normality of Scientists, (3) Attitudes toward Science Inquiry, (4) Adoption of Scientific Attitudes, (5) Enjoyment of Science Lessons, (6) Leisure interest in Science Activities, and (7) Career in Science.
Table 4.8: Linear correlation analysis of student levels of positive attitudes and interests toward science and the three independent variables (Student achievement, parental education, and home language).

<table>
<thead>
<tr>
<th>TOSRA subscales</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>Studen t GPA</th>
<th>Parent Educ.</th>
<th>Home Lang.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Pearson Correlation</td>
<td>1</td>
<td>.476***</td>
<td>.410***</td>
<td>.615**</td>
<td>.616**</td>
<td>.505**</td>
<td>.618**</td>
<td>-.273**</td>
<td>.041</td>
<td>-.089</td>
</tr>
<tr>
<td>Sig. (2-tailed)</td>
<td>.000</td>
<td>.000</td>
<td>.000</td>
<td>.000</td>
<td>.000</td>
<td>.000</td>
<td>.000</td>
<td>.000</td>
<td>.495</td>
<td>.136</td>
</tr>
<tr>
<td>2 Pearson Correlation</td>
<td>1</td>
<td>.263**</td>
<td>.372**</td>
<td>.339**</td>
<td>.222**</td>
<td>.331**</td>
<td>-.149*</td>
<td>-.012</td>
<td>-.030</td>
<td></td>
</tr>
<tr>
<td>Sig. (2-tailed)</td>
<td>.000</td>
<td>.000</td>
<td>.000</td>
<td>.000</td>
<td>.000</td>
<td>.013</td>
<td>.841</td>
<td>.610</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3 Pearson Correlation</td>
<td>1</td>
<td>.475**</td>
<td>.385**</td>
<td>.318**</td>
<td>.387**</td>
<td>-.283**</td>
<td>-.012</td>
<td>-.101</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sig. (2-tailed)</td>
<td>.000</td>
<td>.000</td>
<td>.000</td>
<td>.000</td>
<td>.000</td>
<td>.841</td>
<td>.088</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4 Pearson correlation</td>
<td>1</td>
<td>.666**</td>
<td>.574*</td>
<td>.636**</td>
<td>-.272**</td>
<td>.059</td>
<td>-.015</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sig. (2-tailed)</td>
<td>.000</td>
<td>.000</td>
<td>.000</td>
<td>.000</td>
<td>.320</td>
<td>.805</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>5 Pearson Correlation</td>
<td>1</td>
<td>.771**</td>
<td>.804**</td>
<td>-.257**</td>
<td>.074</td>
<td>.074</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sig. (2-tailed)</td>
<td>.000</td>
<td>.000</td>
<td>.211</td>
<td>.212</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6 Pearson Correlation</td>
<td>1</td>
<td>.787**</td>
<td>-.138*</td>
<td>-.037</td>
<td>.153**</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sig. (2-tailed)</td>
<td>.000</td>
<td>.020</td>
<td>.534</td>
<td>.010</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7 Pearson Correlation</td>
<td>1</td>
<td>-.241**</td>
<td>.007</td>
<td>.028</td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Sig. (2-tailed)</td>
<td>.000</td>
<td>.911</td>
<td>.634</td>
<td></td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

Table 4.9 next page shows the specific contributions of each of the two predictors or independent variables (performance, and degree of parental education) to explaining...
the variability of the dependent variables in the model attitudes and interests toward science as measured by the seven TOSRA subscales).

<table>
<thead>
<tr>
<th>TOSRA Likert-scale Dependent Variable</th>
<th>Independent Variable</th>
<th>Beta (β) Standardize Coefficient</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>GPA</td>
<td>.274 (27 %)</td>
<td>.000</td>
</tr>
<tr>
<td>2</td>
<td>GPA</td>
<td>.148 (15 %)</td>
<td>.013</td>
</tr>
<tr>
<td>3</td>
<td>GPA</td>
<td>.284 (28 %)</td>
<td>.000</td>
</tr>
<tr>
<td>4</td>
<td>GPA</td>
<td>.274 (27 %)</td>
<td>.000</td>
</tr>
<tr>
<td>5</td>
<td>GPA</td>
<td>.260 (26 %)</td>
<td>.000</td>
</tr>
<tr>
<td>6</td>
<td>GPA</td>
<td>.137 (14 %)</td>
<td>.050</td>
</tr>
<tr>
<td>7</td>
<td>GPA</td>
<td>.241 (24 %)</td>
<td>.000</td>
</tr>
<tr>
<td>Subscales Total</td>
<td>GPA</td>
<td>.280 (28 %)</td>
<td>.000</td>
</tr>
</tbody>
</table>

Note: Each number under the TORA subscale title represent the name of each subscale (1) Social Implications of Science, (2) Normality of Scientists, (3) Attitudes toward Scientific Inquiry, (4) Adoption of Scientific Attitudes, (5) Enjoyment of Science Lessons, (6) Leisure Science Activities, and (7) Career in science.

In order to establish how much of the dependent variable mean score variance (TOSRA seven subscales) could be explained by the two independent variables student achievement and parent education levels, a multiple regression statistical tests was performed. This test not only allowed for the determination of the relative contribution
of each of the two independent variables, as well as for the validation of the statistical significance of the results.

The collinearity statistical tests indicated that there was little multi-collinearity between our two independent variables with a Tolerance value of .969 and VIF of 1.032. The Regression Standardized Residuals Normal Provability P-P Plots of each of the TOSRA subscales showed the student scores lie in reasonably straight diagonal lines. The Mahalanobis distances of the multiple regression analyses showed there was only one outlier case with a chi-square value greater than 13.82 (Critical value for 2 independent variables). This outlier case was excluded from the analyses and a new set of multiple regression tests were performed to correct the Pearson correlation results.

The evaluation of the multiple regression tests results also allowed for the determination of the relative contribution of student academic achievement to explaining the score mean variance of the levels of attitudes and interests in science. The Beta Standardized Coefficients for each of the TOSRA subscales confirmed academic achievement (GPA) had made the strongest contribution to explaining the mean score variation in each of the TOSRA scales (See table 4.9 above for specific results).

**Effects of performance alone on student attitudes and interests towards science.**

A one-way between-groups analysis of variance was conducted to explore if the degree of student academic achievement had any impact on the different levels of student positive attitudes and interests in science. Student participants were divided into three groups according to their academic achievement (namely Group 1: A and B, Group 2: C and D, and Group 3: F). This three- group student achievement clustering was performed...
after preliminary ANOVA post-hoc using the Tukey HSD test results indicated there was not statistically significant differences between the A and B achievement student groups and between the C and D achievement student group mean scores. This grouping allowed for a cleaner and more apparent analysis of the results.

Table 4.10: Independent variables or predictors contribution to explaining the variability of the dependent variables in the model.

<table>
<thead>
<tr>
<th>TOSRA Subscales</th>
<th>Model</th>
<th>R Square</th>
<th>Change Statistics</th>
<th>Sig. F Change</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>R Square Change</td>
<td>F Change</td>
</tr>
<tr>
<td>1</td>
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<td>.028</td>
<td>.028</td>
<td>8.14</td>
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<td>.008</td>
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<td></td>
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<td>.052</td>
<td>.051</td>
<td>15.27</td>
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<tr>
<td>5</td>
<td>1</td>
<td>.014</td>
<td>.014</td>
<td>5.06</td>
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<tr>
<td></td>
<td>2</td>
<td>.078</td>
<td>.067</td>
<td>20.45</td>
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<tr>
<td>6</td>
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<td>.003</td>
<td>.003</td>
<td>1.77</td>
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<tr>
<td></td>
<td>2</td>
<td>.016</td>
<td>.016</td>
<td>4.71</td>
</tr>
<tr>
<td>7</td>
<td>1</td>
<td>.015</td>
<td>.015</td>
<td>4.26</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>.050</td>
<td>.041</td>
<td>12.32</td>
</tr>
</tbody>
</table>
The Levene’s test for homogeneity of variances assessed whether the variance in scores was the same for each of the five groups. The Levene’s test statistical significance values across the seven subscale scores was < .05 indicating there was no violation of the assumption of homogeneity of variance. There were statistically significant differences at the \( p < .05 \) level in TOSRA subscale scores for the three student achievement groups: \( F(2, 283) = 8.2, p < .05 \) for five of the seven TOSRA subscales. This data indicated the need to reject the null hypothesis that \( R^2 = 0 \), which stated the degree of positive attitudes and interests toward science were equal based on student academic achievement. In order to determine the specific differences within groups, a post-hoc analysis was performed (see Table 4.11 in page 75 for specific results).

The post-hoc comparisons using the Tukey HSD test indicated there were statistically significant differences in mean score variances among the three achievement groups for five of the seven TOSRA subscales. Specifically, Group 1 (A and B students) conveyed having higher levels of positive attitudes and interests in science than their peers in Group 2 (C and D students), and Group 3 (F students). This trend was observed for five of the seven TOSRA subscales: Social implications of science, Attitudes toward science, Adoption of Scientific attitudes, Enjoyment of science lessons, and career in science. Conversely, there was no significant differences among the three achievement student groups regarding their mean scores for the Normality of scientists and Leisure interests in science subscales (Figure 4 illustrates the effects of the degree of academic achievement on each of the TOSRA subscale mean scores).
Table 4.11: One-way between-groups analysis of variance test results of student mean score differences in attitudes and interests toward science based on academic achievement.

<table>
<thead>
<tr>
<th>TOSRA subscales</th>
<th>Sum of Squares</th>
<th>df</th>
<th>Mean Square</th>
<th>F</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Between Groups</td>
<td>6.872</td>
<td>2</td>
<td>3.436</td>
<td>9.919</td>
</tr>
<tr>
<td></td>
<td>Within Groups</td>
<td>97.345</td>
<td>281</td>
<td>.346</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>104.217</td>
<td>283</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Between Groups</td>
<td>1.311</td>
<td>2</td>
<td>.656</td>
<td>2.601</td>
</tr>
<tr>
<td></td>
<td>Within Groups</td>
<td>70.839</td>
<td>281</td>
<td>.252</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>72.150</td>
<td>283</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Between Groups</td>
<td>9.752</td>
<td>2</td>
<td>4.876</td>
<td>9.468</td>
</tr>
<tr>
<td></td>
<td>Within Groups</td>
<td>144.720</td>
<td>281</td>
<td>.515</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>154.472</td>
<td>283</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Between Groups</td>
<td>6.431</td>
<td>2</td>
<td>3.216</td>
<td>9.912</td>
</tr>
<tr>
<td></td>
<td>Within Groups</td>
<td>91.167</td>
<td>281</td>
<td>.324</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>97.598</td>
<td>283</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Between Groups</td>
<td>15.232</td>
<td>2</td>
<td>7.616</td>
<td>8.962</td>
</tr>
<tr>
<td></td>
<td>Within Groups</td>
<td>238.802</td>
<td>281</td>
<td>.850</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>254.034</td>
<td>283</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Between Groups</td>
<td>3.846</td>
<td>2</td>
<td>1.923</td>
<td>2.549</td>
</tr>
<tr>
<td></td>
<td>Within Groups</td>
<td>211.970</td>
<td>281</td>
<td>.754</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>215.816</td>
<td>283</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Between Groups</td>
<td>11.679</td>
<td>2</td>
<td>5.839</td>
<td>8.201</td>
</tr>
<tr>
<td></td>
<td>Within Groups</td>
<td>200.080</td>
<td>281</td>
<td>.712</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>211.759</td>
<td>283</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
The size effect results (*partial eta squared*) showed these the mean variance for these five subscales as having values > .06. In other words, the degree of student academic achievement can explained 6 percent of the proportion of variance of the mean scores for these five subscales (see Table 4.10 in page 73 for full list of results).

**Figure 4.2**: Illustration of the mean score differences among the three academic achievement groups for each of the TOSRA subscales.
Comprehensive Phenomenological Procedures and Analysis Results

**Research question three.** In what ways do external factors have an effect on Hispanic middle school female students’ perceptions of their self-efficacy, attitudes, and interests and personal aspirations of pursuing a career in science.

By addressing this question, this study explored what factors may influence perceived self-efficacy in science and personal aspirations of pursuing a career in science in seven grade Hispanic female students (as measured through phenomenological study).

With this purpose in mind, a phenomenological explanatory design in the form of semi-structured interviews was used. This design complemented and enriched the quantitative phase and the study as a whole by providing personal perspectives from Hispanic students (an underrepresented minority group in science) of the possible sources of, or lack thereof, perceived self-efficacy in science, which in turn, could influence their attitudes and interests towards this domain (Bandura, 1986). There is evidence self-efficacy serves as a mediator between a student's abilities and subsequent academic performance in that they will avoid those academic tasks in which they lack confidence and choose those in which they feel they will succeed (Schunk, 1985).

**Coding process.**

The qualitative data were collected through administering eighteen face-to-face, open-ended, semi-structured interviews with Hispanic females from the high and low academic achievement (GPA) group, which had previously participated in the survey of the quantitative phase of the study.
The interviews were audio taped, transcribed, and coded by the researcher. The transcriptions of the interviews were coded manually by using the Content Analysis technique recommended by Kvale and Brinkmann (2008). This technique uses pre-identified categories or themes to determine common emerging subthemes or concepts for interpretation and discussion. These main themes constituted key sources of Bandura’s (1981) self-efficacy concept. Important concepts or ideas then were identified and used as subthemes to create the narrative framework, specific to the Hispanic female students’ personal and external experiences and beliefs.

The pre-identified five main themes had been used as main topics of the questions in the interview. The first theme was Personal factors, the second theme was Family – related factors, the third theme was Peer- related factors, the fourth theme was School – related factors, and the fifth theme was Community-related factors.

**Theme number one: internal or personal variable theme.**

Analyses of each theme were conducted to discover possible emergent subthemes. In order to further explore and learn about the first theme which included student personal factors, the answers for question one of the semi-structured interview were used.

In a scale of 1 to 10, with 10 meaning great liking and 0 not at all. The question then goes on to request a self-rating for interests in science and science related activities.

Six main subthemes emerged from the eighteen student answers to this question (listed in order of frequency encountered):

(1) Science is interesting,

(2) Science is boring,
(3) Science is fun and exciting,
(4) Science makes me feel smarter and happy,
(5) I like the discovery. and
(6) Science relates to my future career.

First, a review of the reported interests in science in a scale from 0 to 10; sixteen of the eighteen Hispanic students rated their interests in science between 5 and 10, and the two remaining students rated their interests in science at 2 and 4.

First subtheme: Science is interesting. Four students communicated liking science because it was interesting. Three were from the high-performance range (A and B) and one low performance range (C). Ana stated her interests in science this way:

Well, I like science because it is interesting and you can find a lot of useful stuff. Monica thought the reason why she likes science was because:

Sometimes I do like studying because I get to review interesting things that I like to learn about. Well, because I like to learn new things and all the different discoveries made by scientists.

Second subtheme: Science is boring and I have trouble remembering. A deeper investigation into the two students whose interests in science scale scores were 2 and 4 showed even though their academic backgrounds were from the high performance group, they reasoned and explained their interests in science was low because:

Emilie:

It gets boring and the teachers just talk. I like to do hands on experiments and seeing things is better than being told.
Denise:

I do not like science because sometimes it is boring and I would rather it is boring and I would like to be doing experiments than reading a book. I do not like it because I get bored easily.

These two students perceived science as boring and uninteresting, in addition, both expressed their dislike to learning science by reading a book or just listening to the teacher talk. Looking into their reasons more carefully showed both students had conveyed their predilection for “hands-on” experimental learning.

Third subtheme: Science is fun and exciting. Among the students who stated the reason for being interested in science was because science was fun and exciting, stated it in the following manner, Amanda:

It makes me feel excited about science. Science makes me feel excited because I get to learn new things.

and Rosana thought:

Studying science makes me feel happy and excited because it is fun to learn about new things that I did not know about before. I think I feel that way because when I do an experiment I like how I know that I have accomplished something and I walk out of the room knowing that I have learned something about science.

Fourth subtheme: Science makes me feel smarter, happy, and it is good for my future.
Three students communicated science evokes feelings of being smarter and happier when they explained why they were interested in this domain. Flor expressed her feeling this way:

I like studying science because it relates to what I want to be. Such as the human body. I feel that way because I want to be a good doctor that knows about science.

Rita:

When I am studying it I feel a little smarter than ever.

All these expressions of competence subthemes in science from this group of Hispanic female students, with the exception of the science is boring subtheme, were uplifting and conveyed there is room for specific interventions targeted to increase and keep their positive attitudes and interests toward science alive to take place at this point in their academic career.

Abril, who expressed the second highest rating in her interests in science (score of 8), recently had been reclassified from the English Language Learner category into the main stream student group. Even though, she was having trouble achieving a good grade in science this year, she conveyed the following:

I like science because I like school and I like to do good in school, but I feel frustrated because sometimes I need more help or I do not understand what the teacher is talking about.

This experience confirmed the earlier discussion on the barriers encountered by minority students (literature review section). However, Abril did not allow her
frustration to interfere with the way she felt about her interests and attitude toward science class.

Overall students conveyed positive attitudes and interests toward science, which are important components of an individual’s perceived self-efficacy and competence in this domain. Furthermore, what makes these opinions more encouraging is the fact these attributes are not set in stone and targeted interventions can be put in place to increase and foster such attributes.

*Theme number two: family related external factor theme.*

Data collected from question number two of the interview was used to explore the influence of family practices on student perceived self-efficacy in science—Has anybody in your family talked about girls liking science or science career. How do you feel about it.

*First subtheme: My Mother gives me academic encouragement.* Family members can significantly contribute to the development of a student perceived self-efficacy. Participants recounted their vicarious and verbal persuasion experiences with family members. Verbal persuasions in the form of academic encouragement, from the student’s mothers, emerged as the most significant subtheme and source of perceived self-efficacy. Ten of the eighteen students interviewed reported they had been encouraged mainly by their mothers’ — 4 with a college education, 2 with a high school education, and 4 with middle school education.

It is worth noting this encouragement came from mothers across the three educational levels in the study (Finished college, high school, or middle school). Ten of
the eighteen students interviewed reported they had been encouraged mainly by their mother’s — four with a college education, two with a high school education, and four with middle school education.

Students with college educated mothers like Rosana expressed her mother’s verbal persuasions or encouragement this way:

When I talk to my mom about attending college and studying science I feel happy because she is trying to give me options about the choices I can pick for my career. The way she explains to me about the different types of jobs that is science. I want to learn more about and try to consider going to college to study science.

In addition, Carla stated her experience this way:

My mom encourages me in whatever I want to do as long as it is good. My parents push me whenever I do not want to do it (School work).

Students with high school educated mothers like Abril spoke of her mother encouragement saying:

“I want you to be someone in life.”

My mom is glad I am interested in science, but I am glad my mom does not push me about me liking science.

Julia articulated her encouragement at home:

I and my mom are always talking about how I need to do well in science because I want to be a vet. I will be studying a lot about science and learning.

*Second subtheme: Academic encouragement in the form of negative role modeling.* This form of encouragement came mainly from mothers who did not have a
high education level. This type of encouragement is based on the role models expressing their desired for their children not to be like them, instead to pursue a better future though education.

Students with middle school educated mothers. Four of the eighteen girls had mothers who had only a middle school education and related their mothers’ encouraging statements as follows: Denise and Flor were encouraged by their mothers who model behavior and encouraging words of what not to do and still serve as a positive, motivating force in their life. Denise stated that:

My mom encourages me, she says to try my best and do not to be like her. I feel sometimes annoyed because they repeated way too much.

Flor had the same experience:

I like when she encourages me because she wants me to get a better life than them.

Anita discussed her powerful message she heard from her mother:

Yes, she encourages us and it is interesting because I want to be an engineer and my oldest sister wants to be a doctor.

Evelin explained in a remarkable way the manner in which her mother encourages her in her academic life:

My mother is mostly the one that pushes me to go to college and I appreciate that because one of my main goals in life is to go to college or a university because I want to be somebody in my life and someday in the future (after I have hopefully finished
university or college). When I have children, I would like to set an example to them and push them as well. “I would like to someday have a career in a science field.”

**Theme number three: School-related external factor.**

Girls and women are especially responsive to vicarious experiences and verbal persuasions from their teachers (Zeldin & Pajares, 2000). Various students spoke of the influence their science teacher had had on the development of their competence, attitudes, and interests in science. Eight students reported the importance of having a good teacher has helped their competence, attitudes, and interests in science. Amanda thought:

Having a good teacher also is important to be interested in a class.

Julia described how her teacher had influenced her:

My teacher explains it like no other teacher. I have learned so much this year.

My teacher has taught me in a way I could understand by giving examples, doing experiments, watching videos, and giving lessons. “He has made studying science fun.”

Anita described her teacher efficiency has made a difference:

It is interesting because in 6th grade we barely did anything but read from the textbook and tests which is why I had a D in that grade and this year it’s a lot more fun testing stuff out and finding out what happens.

Daniela narrated how a teacher made a significant impact in her attitude toward science:

Once I went to a field trip and I remember that the lady that showed us around was good at explaining everything to us that day. And whenever one of us had a question
explained it and made it seemed easy. From that day on she made me like science and now I like science, but before that day I hated science because I thought it was hard to learn.

Abril story was significant in illustrating the important role a good teacher plays in influencing student competence. Regardless of recent reclassification to mainstream classes from ELL, she was influenced by someone genuinely interested in science. They change me from ELD to science class and the teacher taught me new things about what people believe and this year I like it even more because our class did experiments and it was really fun!

Seven of the eighteen interviewed students shared they had not been influenced by their science teachers or counselors. However, Denise and Emilia communicated possible reasons for their science teachers not having an influenced on their science competence. Denise expressed:

If my teacher had more patience it would help and if she would not yell at us that much and if she did more experiments.

Emilia experienced similar sentiments about not been influence by her science teacher:

If my teacher was more patient by not getting mad easily and doing more experiments and less projects.

**Theme Number Four: Peers and friends-related factors.**

Several of the interviewed students described peers and friends as important influences in the development of their academic competence. However, these influences were mentioned less often than their family effects. Nine of the eighteen interviewed students
conveyed not having conversations with their peers and friends about college plans or pursuing a science career. However, most of the student narrations were significantly related to discussions they had had about plans of pursuing a college career, but not specifically in science.

Abril expressed her experiences:

We talk about going to college. I am glad I will be able to see my friends in the future and we can get a better job than other people would. We can get more money and live happy.

Amanda stated her feelings:

I feel glad that they want to go to college.

Rosana how she is influenced by her peers and friends:

Yes, sometimes I talk to my friends about college and what we would like to study and I feel pleased with what they think because they can support me with what I decide and give me different options I can choose from.

Anita said:

We talk about our careers in the future and how to get to college.

Evelin related her regrets about the fact that her friends do not worry about college plans at this point in their schooling:

While with my friends we do not usually talk about college. It seems to me that I am the only one in my friend group that works, and hopes to go to college and they support me but they believe that college is something you should worry about in high
school, but I strongly disagree. The time is now to start worrying about college. “Many of my friends do not really like science but are unaware of all the fields.”

**Theme number five: community-related experiences.**

When the girls were asked in what ways their community had influenced them to increase their interests in science, the majority of them related support from the community, in the form of youth groups, science clubs, or science nights from their local colleges, was non-existent.

Monica’s experience clearly illustrates the impact of community and schools exposing children to science from a very young age:

Well, when I was young I went to daycare. When we did not have school, we would do fun things like they would invite a scientist in to show us different things and I thought I would want to do something that cool one day, and as years go on we get to do more science lessons that I am interested in, and I do not mind studying about.

**Chapter Summary**

This study used a sequential explanatory mixed methods design (Newman et al., 2003), where the quantitative results can be used to guide the purposeful sampling of participants for the qualitative phase of the study. The data analyses and interpretation of the quantitative phase of the study was relevant to answering research questions one and two, and the examination and interpretation of the qualitative phase addressed question three. To be able to answer question one — Do attitudes and interests toward science differed among adolescent middle school, female students of diverse ethnic/racial background? — non-parametric between-groups Kruskal-Wallis statistical test was
performed. This test allowed for the comparison of scores on the continuous variables (TOSRA subscale scores) for several groups in the independent categorical variable student ethnicities as suggested by Pallant (2010).

An inspection of the Kruskal-Wallis test results, indicated students of Asian/Filipino Background, conveyed statistically significant different levels of positive attitudes and interests toward science from the other ethnic student groups, for three of the seven TOSRA subscales, $p < .05$ (Enjoyment of Science Activities, Leisure Interests in Science, and Career in Science).

The second research question — Is there a significant correlation in levels of favorable attitudes and interests toward science among high and low academic achievement middle school female students after controlling for other external factors such as parental education level, and home language? — the TOSRA survey data were utilized in the analysis. However, in order to investigate the sole effect of performance on student attitudes and interests in science, preliminary analyses were conducted to establish if there was a possible underlying confounding effect of a second independent variable (Parent Education Level) on these student attributes toward science.

Using zero order correlations suggested that controlling (accounting for) for parent education level had little effect on the strength of the relationship between student attitudes and interests toward science — all correlations between each TOSRA subscale and GPA maintained a $p$ of $< .05$ (seven TOSRA subscales) and performance (GPA). Consequently, a Standard Multiple Regression analysis was performed for each of the TOSRA subscales in order to establish the relationship between student positive attitudes
and interests toward science (as measured by the TOSRA survey subscales) and their performance, as well as, to their parent education level. The Pearson correlation results suggested that of the two independent variables, the degree of parental education, bore a smaller relationship to student attitudes and interests in science than student GPA (sig. <.05).

Results of the Analysis of Variance (ANOVA) tests demonstrated statistically significant values of the relationship between performance and student attitudes and interests in science across the seven TOSRA scales, \( p < .05 \), indicating the need to reject our Null hypothesis that \( R^2 = 0 \).

The third research question — What factors may influence perceived self-efficacy in science and personal aspirations of pursuing a career in science in seven grade Hispanic female students as measured through phenomenological study? — was addressed by the phenomenological explanatory design phase of the study in the form of student semi-structured interviews. This design complemented and enriched the study by providing personal perspectives from Hispanic students (an underrepresented minority group in science) of the possible sources of, or lack thereof, perceived self-efficacy in science, which in turn, could influence their attitudes and interests towards this domain (Bandura, 1986).

Overall results from this phase of the study revealed Hispanic female students having a moderate amount of family support in the form of verbal encouragement was provided mainly by their mothers. It was also uncovered that this verbal encouragement occurred regardless of the degree of the parent education. Unfortunately, encouragement
and support for these students from peers, community, and school was almost non-existent.
CHAPTER FIVE: CONCLUSION

The literature provides considerable information on attitudes, interests, academic achievement, and perceived self-efficacy towards science in high school girls; however, empirical studies of these attributes in middle school girls, especially minority females, are few. This study examined these attributes in middle school girls because these years, grades 5 through 8, are a critical period for American students where self-efficacy, attitudes, and interests in mathematics and science flourish or diminish. (Zeldin et al., 2000).

Empirical evidence suggests achievement in these subjects during middle school most often determines high school choices and enrollment in higher level mathematics and science courses (Singh et al., 2002). In addition, this period is when significant implicit choices are made about choosing and pursuing a science-related career. This stage in a student’s academic career is of prime importance because these attributes can be altered by external factors such as vicarious and persuasive experiences (Zeldin et al., 2000).

The career paths of adolescent girls are highly complex as many talented girls at some stage may contemplate a career in science; however, at some point during late adolescence they change their career plans for a less-challenging one (Arnold, 1995; Eccles, 1994; Farmer, Wardrop, Anderson, & Risinger, 1995). This tendency is reflected in the current significant lack of people of diverse, low socioeconomic status, ethnic, and gender backgrounds in science, math, engineering, and computer technology (SMET) fields (Wai-Ling & Nguyen, 2003).

Research of minority female underrepresentation in STEM is of particular interest
because of their significantly low representation in the country’s current population. An increase in their numbers, especially Hispanic females, in the scientific community, would allow them to enjoy the rewards that come with being part of this well-regarded group.

For a young female to consider a career in the sciences, she needs to be not only academically successful and qualified (Farmer et al., 1995; Seymour et al., 1997), but also open to having a lifestyle and a science career as a viable way of life (Eccles, 1987, 1994). Furthermore, she has to be able to sustain positive beliefs about her science abilities and competencies (Baker & Leary, 1995).

Some educators maintain that cultivating positive attitudes toward science is one of the most desirable outcomes of science education (Von Secker & Lissitz, 2004). Further empirical studies present evidence that positive attitudes promote science performance and career interests by enhancing the possibility the student will enroll in advanced science classes (Carey et al., 1989; Norwich et al., 1990). However, early studies by Simpson and Oliver (1985) presented evidence of a sharp decline in adolescent students’ attitudes toward science especially from grades seven to eight, with their collective attitude toward science leveling near to neutral by the tenth grade.

Consequently, this study explored the extent of diverse ethnic/racial background, middle school female students’ positive attitudes, and interests toward science and the effects of several variables—including academic achievement, ethnicity, and parent educational level — on such student attributes. In addition, it examined the effects internal and external factors may have on building positive self-efficacy in science in Hispanic girls.
This research was designed as a mixed methods study and it was performed in two sequential phases. The first, quantitative, phase explored the scope of student positive attitudes and interests toward science by administering the Test of Science Related Attitudes (TOSRA) survey to 284 middle school female students of diverse ethnic/racial backgrounds. The second, qualitative, phase examined the effects of internal and external factors on perceived science self-efficacy through the administration of personal semi-structured interviews to 18 middle school Hispanic girls who had participated in the survey phase of the study.

The data from the TOSRA survey were used to answer the first and second research questions while the data from the interviews provided important insights into the sources of Hispanic students’ perceived self-efficacy in science. This study’s conclusions and discussions are presented following the orderly succession of the research questions.

**Research Question One**

The first research question inquired if student ethnicity/race background contributed to differences in positive attitudes and interests toward science. To explore the possible effects of student ethnicity on the degree of positive attitudes and interests toward science, the mean variance of each of the seven TOSRA subscales based on ethnicity were evaluated using the non-parametric between-groups Kruskal-Wallis H statistical test. This test allowed for the assessment and comparison of scores on each of the continuous variables or TOSRA subscales for several groups in the independent categorical variable — student ethnicities (Pallant, 2010).

The Kruskal-Wallis test results indicated that middle school female students of Asian/Filipino background conveyed statistically significant higher levels of positive
attitudes and interests toward science when compared to their peers of other ethnic
groups for three of the seven TOSRA subscales, \( p < .05 \) (Enjoyment of Science
Activities, Leisure Interests in Science, and Career in Science). These results suggested
Asian/Filipino middle school female students enjoyed and were more attracted to
classroom and extracurricular science related activities than the other ethnic group
counterparts. Furthermore, Asian/Filipino students conveyed being more interests in
pursuing a career in a science-related field. These results led to the rejection of the Null
hypothesis of \( R^2 = 0 \) and construed the levels of the attributes, Enjoyment of Science
Activities, Leisure Interests in Science, and Career in Science differed among middle
school females of different ethnic backgrounds.

The result from this analysis is reflected and reinforced by the conclusion of a
three-year trend (2004, 2005, and 2006) study by the California Department of Education
for the CST (CDE, 2007), that showed that 80 percent of second and third grade students
Filipino descent scored at the proficient level or higher. In addition, this academic
tendency continued into the high school years where, in California, Asian students have
the highest completion rates (59\%) of courses required for acceptance by the University
of California (UC) or California State University (CSU) systems, followed by Filipino
(50 \%) and Caucasian students (46 \%). Thus, compared to other groups, Filipino
students are doing fairly well in completing college preparation courses. The
foundations for this academic upper movement has been credited to the fact Asian-
American parents tend to encourage their daughters and sons equally to excel in
quantitative and scientific subjects and to pursue scientific and technical careers
(Campbell, 1991).
When the findings in this study are analyzed through the proposed collaborative Bandura-Ogbu theory of learning framework, the importance of verbal persuasion and encouragement one receives as a source of self-efficacy (and therefore positive attitudes and interests) in a specific domain becomes clear (Bandura 1986, 1997). For instance, verbal persuasion has been shown to exert the greatest effect on people who already believe themselves capable of accomplishing a particular activity (Bandura, 1997). The outcomes of this inference can be recognized when the results of the study data indicate students of Asian/Filipino ethnicity conveyed a higher degree of positive attitudes and interests in science as well as receiving significant verbal encouragement from their parents than their peers of other ethnicities (Campbell, 1991). However, this study does not imply that parents of other ethnicities than Asian/Filipino do not encourage their children to perform academically.

The extent of positive attitudes and interests toward science (as measured by the TOSRA survey) of the middle school Hispanic female students in this study are of critical significance and mirror the current lower numbers of Hispanic females who enrolled in advanced courses in high school during the 2008-2009 school years, when compared to their peers. Specifically, Hispanic females enrolled in mathematics (10 percent), chemistry (13 percent), and physics (4 percent) courses compared to their counterparts. Asian students’ participation was at 36, 24, and 11 percent respectively, and Caucasian students were at 12, 16, and 6 percent respectively (CPEC, 2010).

Regardless of these reports, it is worth mentioning in this study that Hispanic students acknowledged enjoying in- and out-of-class science activities and having an interests in pursuing a science career (as measured by these three TOSRA scales). Even
though, their mean scores for their attitudes and interests did not reach the levels seen in their Asian/Filipino peers (variance between score ranks did not reach statistical significance, \( p > .05 \)). This statistic is important because it suggested these middle school Hispanic females’ views of science were moderately acceptable. This characteristic is significant in the context that the Hispanic female — one of the Underrepresented Minorities in Science, URM— is the largest minority ethnic group in the U.S. and their participation in science careers would significantly increase the diversity of the scientific community.

Results reported by the NWLC & MALDEF (2009) emphasized that Hispanic female students had big dreams for their futures, which included professional careers. They understood that education is key to accomplishing their goals. A number of the students reported the desire to become doctors, nurses, lawyers, and scientists. Data from the 1988 cohort of the National Education Longitudinal Study brings to light that minority students are equally as enthusiastic about pursuing science and math careers as non-minority students at an early age. In spite of this early interests, Hispanics face difficulties in developing their skills and engaging in those interests because of a lack of resources needed to foster their learning in science and mathematics (Peng, et al., 1995; Auerbach, 2004). At this point in their educational pipeline Hispanic female students are more afraid to ask questions during class discussions, are less likely to report, are looking forward to taking eighth grade mathematics classes, and are the least likely of any group to aspire to STEM careers (Catsambis, 1995).

Surprisingly, the Caucasian student group in the present study did not convey high levels of positive attitudes and interests in science at this specific point of their
academic careers. Their attitudes and interests toward science scores at this juncture did not correlate with the high numbers of Caucasian female students who enroll in AP science classes in high school and the total degrees in science, engineering, and mathematics they earned (NSF, 2010). Most importantly, future studies need to investigate more closely the foundations for this change in attitude and interests toward science. Results from these suggested studies could lead to the finding of specific factors or practices which can help minority students enhance their participation in science courses in high school.

Alternatively, Ogbu’s date cultural ecological perspective may inform this study’s results by categorizing the other ethnicities different from Caucasian and Asian/Filipino as “involuntary minorities” whose lower academic achievement and oppositional attitudes toward established institutions in society were a type of a “survival” adaptation strategy even though they hindered their academic successes. Again, these study findings have to be interpreted with prudence because of the significant drawback in Ogbu’s theory in which there is little room for an explanation of the existence of involuntary minority high-achievers whose motivation to strive and succeed are rooted in their experiences as community participants (Foster, 2004).

**Research Question Two**

When addressing the second research question — To what extent does academic performance influence student positive attitudes and interests toward science? — the TOSRA survey data were employed in the analysis.

To investigate the sole effect of performance on student attitudes and interests in science, preliminary analyses had to be performed to establish if there was a possible
underlying confounding effect of a second independent variable (Parent education levels) on the student attributes toward science. Partial Correlation Statistical test results, indicated by the normal Pearson product-moment correlation matrix, showed a small positive relationship between these variables (Pearson correlation = .176, \( p < .005 \) at the 2-tailed level) indicating these two variables shared only three percent of their variance (implied by its coefficient of determination) and there was not much overlap between these variables.

Second, a one-way between groups analysis of variance (ANOVA) was conducted to explore if the degree of parent education had any impact on the extent of student achievement. Even though there was a positive tendency on the differences between the four levels of parental education and student achievement, none of these values showed a statistically significant result. The preliminary analysis data did not adhere to the empirical figures reported in the literature, which suggests the degree of parental education directly and positively influences student academic achievement (Jimerson, Egeland, & Teo, 1999; Kohn, 1963; Luster, Rhoades, & Haas, 1989). Furthermore, the literature suggests the level of parental education influences the beliefs and behaviors of parents leading to positive outcomes for the children (Eccles, 1993).

Alexander, Entwistle, and Bedinger (1994) observed parents with higher education formed beliefs and expectations of their children’s achievement that were more closely related to their children actual achievement than did parents with lower education levels. In other words, less-educated parents’ high performance beliefs and expectations for their children’s achievement did not totally correlate to their children’s actual performance.

Smith, Brooks-Gunn, and Klebanov (1997) argued the home environment
mediated the association between the degree of student achievement and the level of parental education. Interestingly enough, this intercession affect was found to be stronger for maternal education level than for family income. Subsequently, these authors hypothesized student education achievement, parental education, and home environment might be linked to specific positive performance behaviors in the home such as reading, playing, and more cognitive stimulating behaviors and attitudes.

After establishing that the degree of parental education in this study did not produce any statistically significant influence on student levels of performance in science, the researcher moved on to the investigation of the possible confounding effects these two independent variables could exert on student positive attitudes toward and interests in science. The results of the partial correlation statistical analysis for the second model (controlling for degree of parental education, Table 4.7 in page 69) suggested there was a small, positive relationship between each of the seven TOSRA subscales and the degree of student performance (all with $p < .05$). A closer inspection of the zero order correlations in the second model suggested that controlling (accounting) for parent education level had little effect on the strength of the relationship between student attitudes and interests in science and student performance (performance effects sustained a $p$ of $< .05$ for the seven TOSRA subscales). Further analysis through multiple regression tests suggested that of these two independent variables, performance (GPA) provided the greatest contributions to the variance of the degree of positive student attitudes and interests in science.

The impact of performance on student attitudes and interests toward science, in this study, revealed there was a statistically significant influence on student academic
achievement on six of the seven TOSRA subscales with the exception of Leisure interests in science (See Table 4.8 in page 70 for F and p values). These statistical test results suggested there were significant differences between academic achievement, student groups, and the degree of positive attitudes and interests toward science. In other words, these results implied high achieving students (A and B group) in general had more favorable attitudes and interests towards science (as measured by the Social Implications of Science, Attitudes toward Scientific Inquiry, Adoption of Scientific Attitudes subscale, Enjoyment of Science Activities, and Career in Science). These favorable attitudes and interests towards science included:

(1) Accepting attitudes towards the social benefits and problems associated with scientific progress and research,
(2) Having higher levels of positive attitudes toward scientific experimentation and inquiry as methods of obtaining information about the natural world,
(3) Accepting scientific inquiry as a way of thought and how likely students are to change their way of seeing the world,
(4) Manifesting higher rates of enjoyment of science learning experiences in the classroom,
(5) Expressing a higher degree of interests in pursuing a future career in science.

That the present findings signal evidence of a positive link between attitudes toward science and achievement is supported by previous studies (Schibeci, 1986; Peterson & Carlson, 1979) that show that the existing relationships between student background variables such as ethnicity, parental education, student achievement, and
positive attitudes toward science.

A word of caution is necessary when interpreting the results of this study that achievements influence attitudes and not the reverse as reported by other research (Schibeci, 1986). One must impose a chronological order on the variables of the study in order to imply a conclusion. Other reported research studies also concurred with this study’s findings about the relationship between achievement and related attitudes toward the specific subject (Wilson, 1983; Marsh, 1992; Weinburgh, 1995).

Singh and colleagues’ (2002) studies suggested science achievement among eighth graders was influenced by motivation, attitudes, and academic engagement. Most importantly, those studies argued that these results were encouraging because the variables are malleable and subject to change. School-related motivation and science attitudes could be positively influenced by more engaging school-related experiences and better instructional approaches. These authors’ proposals carry significant implications for educational practice since targeted intervention programs could be created to increase and foster these academic positive attributes.

The present study findings, on the implications of the degree of academic achievement on the levels of positive attitudes and interests toward science conveyed by middle school female students, revealed to be in agreement with this study’s Bandura-Ogbru learning theory framework. Bandura (2005) contended that the higher the students’ perceived efficacy in a domain (in this case performance or GPA in science):

(1) the wider the career options they seriously consider pursuing,

(2) the greater interests they have in them,

(3) the better they prepare themselves educationally for different occupational
careers,

(4) the greater their staying power in challenging career pursuits.

**Research Question Three**

Addressing the third research question — To what extent do external and personal factors (parental education, language spoken at home, verbal persuasions, and vicarious modeling) account for adolescent female students’ perceptions of their self-efficacy, attitudes, interests, and personal aspirations of pursuing a career in science?

Quantitative and qualitative methodologies were used in an effort to answer this question. First, the TOSRA survey results (Quantitative methodology or Phase 1) explored the possible influence of certain external environmental factors (parent education level and home language) on attitudes and interests levels toward science.

Second, the semi-structured interviews complemented and enriched the quantitative results by providing personal perspectives of Hispanic students (an underrepresented minority group in science) of the possible sources of, or lack thereof, self-efficacy in science, which in turn, could shape their attitudes and interests (Bandura, 1986).

After analyzing for differences in mean scores for the TOSRA’s seven Likert-type scales in terms of parental educational level (Group 1: one or two parents finished college, Group 2: one or two parents finished high school, and Group 3: One or two parents finished middle school), none of the mean scores for the seven scales showed differences that were statistically significant. Even though, Group 1 mean scores across the seven scales were consistently higher than those for Group 2. There were some mixed results for Group 3 across the scales; however, one must remember that this
group had only 10 students and deriving any conclusion from these results could have been misleading.

**External factors.** While nearly 40 percent of Hispanic students come from homes in which parents have not completed even high school education; this is true for only four percent of Caucasian students. Another important aspect of formal education is the cultural capital (knowing how things work) and social capital acquired while earning a diploma or a college degree (Gandara et al., 2009).

**Family related factors.**

The study’s qualitative phase or personal semi-structured interviews with the group of Hispanic female students supplemented and enhanced understanding of the effects of external factors--family, school peers, and community dynamics--which play a role in the development of perceived self-efficacy in science.

Participants recounted their vicarious and encouragement experiences with family members. Mothers emerged as the most significant sources of verbal persuasion, in the form of academic encouragement to their daughters, and this significance held for mothers across the three educational levels in the study (finished college, high school, or middle school). Ten of the eighteen students interviewed reported being encouraged mainly by their mothers -- four with a college education, two with a high school education, and four with middle school education.

The girls’ experiences based on the level of their parent education level is reported to emphasize the fact that regardless of the differing education levels mothers still could be significant influences in their daughters’ academic achievements.

These results are supported by studies, which also indicated major factors
associated with daughters’ academic levels of aspiration include: mother's encouragement, importance of daughter's education to mother, and mother's aspiration of academic level for daughter (Hernandez et al., 1994). Parents also have been most frequently named in providing encouragement (Sanchez, Reyes, & Singh, 2006) and in playing a major role in motivating their children to achieve their educational goals, despite the parents’ limited educational levels (Arellano et al., 1996), providing support to this study finding.

The degree of parent education had a significant effect on student science academic achievement. Even though performance is part of the intrinsic or internal student attributes affecting perceived self-efficacy, the results of the differential relationship it has with the degree of parental educational, shows that sometimes there is a reciprocal relation among these three factors. In other words, the level of parent education affects student academic achievement, attitudes, and interests toward science. In addition, the degree of academic achievement influences student positive feelings and motivation toward science. Therefore, these results suggest how closely interrelated these attributes are to one another. However, achievement, attitudes, and interests in science are malleable variables, which can be changed by positive interventions.

Arellano and Padilla (1996) reported that parents with low educational levels essentially did whatever they could, including tutoring and teaching their children, until their children’s educational level exceeded their own. Parents might have realized the limits of their support and perceived the necessity for other adults to become involved in their children’s lives. The informational and experiential support provided by parents with limited education mostly involved sharing the experiences and struggles they
encountered in Mexico and the United States because of poverty and a lack of education. This support was integral to some students’ successes. Parents offered this information as a way to encourage their children to take advantage of the opportunities they did not have. Students also reported that observing their parents’ experiences because of not having an education motivated them to achieve to a higher degree.

Results from the analysis of the effects of parent education level on student performance showed students with middle school educated parents had statistically significant lower academic achievement than those whose parents finished high school and those whose parents finished college. Even though there was a difference between students with college educated and high school educated parents, the difference level did not reach statistical significance. Research studies (Von Secker, 2004) have showed low achievement among students whose parents have a low education level has been correlated to low socio-economic level, resulting in having fewer learning resources at home. On average, science achievement of all students in Grades 4, 8, and 12 was significantly higher when one or more parents had graduated from college and when home environments were more advantaged, regardless of which school those children attended. While science achievement of children from families of average SES or above remained consistently higher, the gap in achievement for poor children with or without these resources widened between 4th and 12th grades (Von Secker, 2004).

While there has been an outcry for role models for students to model themselves after, studies with Mexican high school youth showed that individuals can model behavior of what not to do and still serve as a positive, motivating force in one’s life (Stanton-Salazar & Spina, 2003). This is similar to what Azmitia, Cooper, García, &
Dunbar (1996) found in their study, called negative role modeling. Observing parents’ experiences and hearing about their life struggles, albeit negative, indeed affected students’ desire to obtain an education.

Even though parent education level had a small effect on student degree of positive attitude and interests toward science, it did not reach statistical significance. On the other hand, parental educational level had an impact on science academic achievement. It should be clarified that if parental education level affects science academic achievement, academic achievement affects attitude and interests toward science, then, one wonders if it equally translates into parent education level having a direct effect on student attitudes and interests in science.

It appears parental academic encouragement (regardless of their educational level) indeed positively affected student science attitude and interests — however, not enough to reach statistically significant levels. Furthermore, this encouragement was not sufficient to make a positive difference on student academic achievement. This study is not suggesting in any way parental encouragement is the only variable playing a role in student science attitudes, interests, and academic achievement.

Gandara’s (1982) studies on high-achieving Mexican-American female students found these students tended to rely significantly more on their parents for emotional support than their male counterparts. These females received less support from their fathers, who saw them taking more traditional futures. In addition, Gandara reported these girls received less support from external sources such as teachers and peers.

**School related factors.**

Science instruction in the early years can provide the necessary opportunities for
young children to develop basic understandings of natural phenomena and fundamental processing skills such as observing, inferring, and exploring. Thus, experiential science education in early childhood is of great importance to many aspects of child development, and researchers suggest that science education should begin during the early years of preschool (Eshach, 2003; Eshach & Fried, 2005; Ginsburg & Golbeck, 2004). Results reported by Sacks, Trundle, Bell, & O’Connell (2010) supported the belief that experiences in kindergarten and early elementary grades reduce the influence of SES difference between children with high and low SES as they move into elementary school.

Curriculum also played an important part in the level of positive attitudes and interests toward science. The main themes emerging from the students’ stories included the significance of more “hands-on” experimentations, field trips, and exposure to real life scientists who could show them what they do in everyday jobs. Several studies (Von Secker, 2002; Von Secker et al., 1999) have proposed that, in science, the academic resilience of minority students might be improved when teachers emphasize pedagogical practices providing greater access to laboratory experiences.

Typically, a student decides to become a scientist between fourth and six grades (Smoot et al., 2001). Minority students, especially African American females, need early experiences to motivate them to continue to study and participate in science. They respond to both intrinsic and extrinsic motivation. Intrinsic motivation emphasizes process in mastering a goal. Signs of intrinsic motivation include enjoyment, curiosity, challenging experiences, and solving difficult and new tasks. Extrinsic motivation focuses on outcomes with a reward in grades and recognition (Smoot et. al., 2004). Five
of the nine barriers, identified by Fear-Feen and Kapostasy-Karako (1999), to female enrollment in mathematics and technological sciences in high school are related to teacher characteristics, attitudes, and practices. The barriers include: (a) lack of self-confidence, (b) learning environment, (c) teacher behavior, (d) lack of female role models, and (e) failure to see the relevance between the classes and a female's expected role in life.

Sherman & Weber (1999) reported a need to increase the participation of minority females in science and mathematics and involve girls interacting recreationally and at science stations with other young women and established women scientists. They engage in real mini-research projects, studying such things as the environment and physical fitness. They share information with their parents, teachers, and other students. The teachers show parents how to be involved at home. Discussions with the girls encourage them to reflect on and share what works in the classrooms as well as the styles of teaching that appeal to them.

**Community related factors.** The present study showed the participating middle school female students were lacking critical community support and encouragement, which is essential to foster a preservation of self-efficacy in science. Most of the participating students conveyed their desire to have scientists in the classroom and meet professionals who could show them the different day to day work they do.

**Peer-related factors.** Even though this study did not determine the specific reasons for the students’ lack of conversational engagement about science, the literature suggested that students from underrepresented groups are susceptible to negative stereotyping from their peers (Steele, 1997; Taylor & Antony, 2000). A stereotype threat
is a psychological predicament in which people fear being evaluated in terms of a negative stereotype about a group to which they belong. As a result, stereotype threat may create anxiety and self-doubt, lowering performance in relevant domains. On the other hand, data reported by Hernandez and his colleagues (1994) showed that support of the family, schools, and peers was an important factor for Hispanic females completing high school and taking non-traditional career paths.

**Internal factors.** Positive attitudes and interests toward science are important components of an individual’s perceived self-efficacy and competence in this domain. However, these attributes are not set in stone. When interviewed, girls were asked to rate their interests in science, on a scale from 0 to 10 (with 0 not interested at all and 10 very interested), 16 of the 18 girls rated their interests in science between 5 and 10. These results are encouraging because even girls who were not performing well in the course expressed interests in science class. In fact, the second highest rating (8) came from Abril who recently had been reclassified and was having trouble achieving a good grade for her academic year. She conveyed the following:

I like science because I like school and I like to do good in school, but I feel frustrated because sometimes I need more help or I do not understand what the teacher is talking about.

These experiences confirmed the earlier discussion on the barriers encountered by minority students (Gandara & Contreras, 2009). However, Abril did not allow her frustration to interfere with her interests and attitude toward science class.

Three main themes emerged when the girls were asked to explain the reason for their interests in science (1 most frequent; 2 less frequent and 3 least frequent):
1. Science is interesting and one gets to learn many interesting things.

2. Science is fun and makes me feel happy and excited.

3. I feel smarter.

These expressions of competence in science from this group of Hispanic girls are encouraging and convey that there is room for specific interventions to take place at this point in their academic career. Those interventions should target increasing and keeping their positive attitudes and interests toward science alive.

**Implications and Recommendations for Educational Practices**

The evaluation of this study’s results has led to the identification of four areas of significant priority for immediate practical and academic actions. These actions may help underrepresented girls develop as well as foster positive attitudes, interests, and perceived self-efficacy in science during their important middle school years. These recommendations call for interventions and strategies involving these areas for student academic and practical support: family, school, peer, and community. For the interventions and strategies to work, however, concerted efforts in all four areas need to be implemented if true changes are to be made in increasing the participation of underrepresented minority females in the science fields.

Even though these recommendations could be considered general in nature, they are reported in the literature to be effective means of intervention to increase attitudes, interests, and self-efficacy toward science.

**Priority area 1.** The success of any coordinated effort rests primarily on the practices each student is exposed to at home to develop positive academic attitudes, interests, and perceived self-efficacy. Regardless of how many peripheral sources of
academic student support are offered outside the home, maintaining and promoting parent encouragement has proven to play a significant role in helping develop a strongly perceived self-efficacy. This encouragement should stress the importance and value of science skills and encourage girls, particularly underrepresented minority girls, as they face academic and social obstacles... As reported by Leslie and colleagues (1998), family support and engagement through educator-parent programs are critical to the promotion of student attitudes, interests, and commitment to science careers.

The results of this study have shown that Hispanic female students are been taught, at home, to foster for the most part positive attitudes, interests, and most importantly, a healthy academic perceived self-efficacy. Consequently, it is important to take advantage of this preexisting and significant source of student academic attributes. One of the most important undertakings should be to develop a close partnership between school and parents in the form of parent training sessions. It is essential that parents are educated and informed of the importance of and best practices for fostering a positive academic home environment. For instance, subtle messages that convey the notion girls are not as capable as boys in mathematics and science may not be the best practice to incentivize positive self-efficacy in science in girls and can affect children's attitudes and achievements, especially in mathematics (Tsai & Walberg, 1983). The interactions between parent and daughter should include encouragement for the girls to explore, take risks, develop independence, and engage in mathematics and science games that help develop spatial and critical reasoning (Morgan, 1992; Mullis & Jenkins, 1988; Vetter, 1996). In addition, an equal parental educational and career expectation should be fostered toward sons and daughters (Eccles and Jacobs, 1986; Casserly, 1980).
The Mother-Daughter Program developed at the University of Arizona and the University of Texas, El Paso, School of Education (Excelencia in Education, 2010), could serve as a template to establish an outreach initiative or intervention. This program organizes activities to help girls and their mothers work together to set goals that will lead to academic and career success for the adolescents. It involves the mother-daughter teams for one year in monthly educational and career activities and follows with workshops and seminars in subsequent years.

Results from longitudinal studies have shown that of the 1,800 mothers and daughters who participated in the program, between 1986 and 1993, fewer girls (than those in the comparison group) dropped out of school or got pregnant than did non-participants from similar backgrounds. Participants were also more likely to enroll in advanced courses, earn higher grades, and outscore their peers on state achievement tests. For example, 98 percent of the girls in the first two cohorts – 1986 and 1987 – were still in school in 1992; 62 percent were enrolled in college preparatory courses; and almost 50 percent were enrolled in honors courses (Excelencia in Education, 2010).

School officials should be aware of the significance of school-parent outreach programs being conducted in languages other than English. The lack of fluency in the English language keeps many parents from participating in school activities and advocating for their children. Sosa (2002) has gathered and published a comprehensive list of critical issues, many of which go unspoken due to the fear of infringing into privacy; however, they must be resolved before designing a well-rounded outreach parent awareness program. These issues include: no family tradition of higher education, fear of “Anglo-influence,” early pregnancy, parent’s fear of the children leaving home, and lack
of family commitment to higher education for their daughters (Sosa, 2002).

**Priority area 2.** School related interventions are numerous and they may include the following:

*Early age intervention:* Aims to increase women and underrepresented minorities in STEM should start at an early stage of the educational pipeline K-16. Most importantly, they should be made aware of the importance of achievement, preparatory courses, and career choices.

*Early exposure to science “hands-on” activities:* Development of a curriculum with more manipulative types of activities has been shown to foster student attitudes and interests mainly in science.

*Providing science teachers with professional development programs:* Science teacher efficacy is critical to engage and motivate students in science classes. Promoting K-12 teacher competency in science should be treated as an urgent matter. School officials and credentialing institutions should create partnerships to maintain a proficient pool of science teachers through ongoing seminars and professional development programs.

*Academic and career counseling:* Unfortunately counseling is often weak in predominantly minority secondary schools (NAS, NAE, & IM, 2011). However, the weakness can be counterproductive for the national scientific and technological future, steering minority students into less demanding courses and programs when counselors could be challenging students by encouraging them to take the highest level courses they are prepared for.

Math skills are considered essential to success in STEM fields (AAUW, 2010).
Fewer girls than boys take advanced placement (AP) exams in STEM-related subjects such as calculus, physics, computer science, and chemistry. Students from historically disadvantaged groups such as African American and Hispanic students, both female and male, are less likely to have access to advanced courses in math and science in high school, which negatively affects their ability to enter and successfully complete STEM majors in college (May & Chubin, 2003; Frizell & Nave, 2008; Tyson et al., 2007; Perna et al., 2009).

In 2005, 31 percent of Asian American and 16 percent of white high school graduates completed calculus, compared with 6 percent and 7 percent of African American and Hispanic high school graduates, respectively. Additionally, one-quarter of Asian American and one-tenth of white high school graduates took either the AP or International Baccalaureate exam in calculus, compared with just 3.2 percent of African American and 5.6 percent of Hispanic graduates (National Science Board, 2008).

Providing the sufficient and necessary support for girls enrolled in advanced classes: Academic support is an imperative component of a well-designed, school-related intervention. Several practical steps can be taken to increase the completion of advanced classes by minorities by making their success a priority. Academic reinforcement in the form of tutoring before or after school can be useful to foster and maintain student interests in the subject.

In addition, schools need to identify “choke points” such as course availability, make course transfer easier, and ensure that courses are structured to properly support students. Not only higher education institutions can address these issues and ensure the academic and social support necessary for underrepresented minority students in STEM
is in place, but middle and high schools need to recognize that their role in student support is critical for student success.

*Teacher encouragement and outreach to minority female students:* Teachers can try to connect with minority students by using practices such as making eye contact, allowing ample time for them to respond to questions, and creating a sense of community and participation in the classroom. In addition, using examples in the classroom, which are inclusive of female minorities who have succeeded in science fields, listening carefully and respectfully to students’ comments and questions, and encouraging students who seem reluctant to talk can provide the encouragement these girls need.

**Priority area 3:** Local community colleges and scientific industries often have community involvement or outreach programs in place. Many institutions are eager to partner with local K-12 schools as means of promoting future science students and a work force. They also provide scientist visits to schools where students can interact with real life science professionals and experience “hands-on” activities using the latest technology available. Community colleges and universities offer science summer camps geared to minority students. The iQuest (investigations for Quality Understanding and Engagement for Students and Teachers) project was designed to promote student interests and attitudes toward careers in STEM. The project targets seventh- and eighth-grade science classrooms that serve high percentages of Hispanic students. The project model offers student summer camp programs and professional development for science teachers, and it has led to successful increases in student performance (Hayden, Youwen, Scinski, Olszewski, & Bielefeldt, 2011).

The significant influence of community involvement in student attitudes and
interests toward science was clearly revealed by two of the students in the interview phase of the study.

Once I went to a field trip and I remember. The lady that showed us around was good at explaining everything to use that day. And whenever one of us had a question she explained it and made it seemed easy. From that day on she made me like science and now I like science, but before that day I hated science because I thought it was hard to learn.

Well, when I was young I went to daycare. When we did not have school we would do fun things like they would bring a scientist in to show us different things and I thought I would want to do something that cool one day, and as years go on we get to do more science lessons that I am interested in, and I do not mind studying about it.

Community- school partnerships are essential in conveying minority adolescents that future science careers are not out of reach.

Priority area 4. Development of peer group related interventions such as the creation of science clubs on school grounds can be a positive venue for students to find peers who share the same academic interests. Discussions among peers can have a powerful influence over decisions a student might make about their future school and career. Academic encouragement among peers was evident during interviews with the Hispanic female students. Several students conveyed having academic discussions with her peers. Four of the most meaningful responses mentioned the following:

“We talk about going to college. I am glad I will be able to see my friends in the future and we can get a better job than other people would.”
“We can get more money and live happy.”

“Yes, we talk about school. I like how my friend teaches me
Many other interesting things how to get extra points.”

“My girlfriend and I encourage each other to do well. I hang
out with good students. We talk about our careers in the future and
how to go to college.”

**Recommendations for Further Research**

Future studies are needed to investigate in more detail if there is a specific and

critical transition point between the eighth and tenth grades where Caucasian female

students decide to engage in science and science related activities. This could explain

their current numbers in high school AP science courses. Most importantly, it is essential

future studies engage more closely in exploring the foundations for this change in attitude

and interests toward science. Results from these suggested studies could lead to the

finding of specific factors or practices, which can help minority students, enhance their

participation in science courses in high school.


Further studies are needed to investigate and compare the degree of positive

attitudes and interests toward science in early-age elementary school female students,

with the purpose of establishing if intervention programs are necessary at a specific point

in their education. Such information could help develop and foster these positive

academic attributes.


More detailed research is necessary to learn which intervention programs are

producing satisfactory results in developing and fostering strong positive academic

attitudes, interests, and self-efficacy toward science in female students, nationally, as well
as internationally. Such research could lead policy makers to support science curriculum modifications to include community, family, and school involvement.

Limitations

Several cautions are in order. First, issues of ethnic/racial group representativeness and generalizability of the results are worth mentioning, mainly when these results can have implications for academic practice. This study provides results representative of this specific student population and they should not be generalized to groups other than the actual study participants (Maxwell, 1992).

One limitation of the study was that the sample included only seventh-grade female students in a southern CA middle school, thus decreasing the validity in generalization of results to all middle school female students. A second limitation of the study was the use of the end of the academic year grade point average (GPA) as the measure of science achievement to be measured against attitudes and interests toward science. Grading practices vary from teacher to teacher, are not standardized, and a standardized science test score was not available for seventh-grade students. Standardized science tests are available in California for eighth and tenth grades.

A third limitation of the study was the self-reporting of ethnicity done by students in the survey, mainly when it came to the reporting of mixed ethnicity. When reporting mixed ethnicity, it is important to recognize an individual can be of mixed ethnicity, but identify with one more than the other.

A fourth limitation of this study was researcher educational and ethnic/racial background. She is a Hispanic female in science. Possible bias may have entered into the phenomenological interpretation and construction of the meaning of the semi-
structured interviews. Even with the researcher’s bias removed, the results obtained
could potentially be subjective depending on the reader’s interpretation.
APPENDIX A

Human subjects Research Approval Form

Human Subjects Research Approval Form

IRB #: 2012-107

To: Katherine Hayden
   Ana L. Dowey

Project Title: Considerations For The Low Minority Female Student Achievement And Participation in Science

This letter certifies that the above referenced project was reviewed and approved by the University’s Institutional Review Board in accordance with the requirements of the Code of Federal Regulations on Protection of Human Subjects (45 CFR 46), including its relevant subparts.

Continuing Review
This approval is valid through the expiration date shown below. If this research project will extend beyond that date a continuing review application must be submitted at least 30 days before this expiration using the Continuing Review form available on the IRB website (www.csusm.edu/irb).

Modifications to Research Protocol
Changes to this protocol (procedures, populations, locations, personnel, etc.) must be submitted and approved by the IRB prior to implementation using the Minor Modification Form available on the IRB website.

Unanticipated Outcomes/Events
The CSU San Marcos IRB must be notified immediately of any injuries or adverse conditions.

☑ Approved Information Sheet or Consent Form(s) are attached. Only approved consent form(s) may be used to obtain participant consent.

Approval Date: 5/25/2012
Expiration Date: 5/24/2013

Katherine Hayden, Ed.D.
IRB Chair

The California State University
San Marcos
California State University San Marcos  IRB Approved Parent consent and Student
Assent form to participate in phase 1 (survey) of the research.

Consent to Participate in Research

Invitation to Participate

Ana Dowey, a student in the joint doctoral program at California State University San Marcos (CSUSB) and University of California, San Diego (UCSD), is conducting a study that seeks to identify and better understand practices that foster self-efficacy in science in students of diverse ethnic/racial backgrounds. The findings will inform school officials on how participation of underrepresented minority students may be increased in science, technology, engineering, and mathematics (STEM) fields. We are extending an invitation to all seventh grade female students to participate in this study.

Participating students will take a survey that asks questions about how they feel about science topics and a few background questions such as her ethnicity, parental education level, and main language spoken at home. Some students will be invited to take a follow-up interview. Students who are selected for the interview will be asked to describe in more detail their feelings about science and why they feel that way. In addition, the researcher will review benchmark science grades for participating students. However, no student names will be used, instead student identification numbers will be listed.

Participant’s name

Date

Participant’s Signature

Parents’ Name

Parents’ Signature

Researcher’s Signature

This document has been approved by
the Institutional Review Board at
California State University San Marcos
Expiration Date: May 16, 2013
Consentimiento para Participar en una Investigación

Invitación para Participar

Ana Dowey, una estudiante del programa de doctorado de la Universidad Estatal de California en San Marcos (CSUSM) y de la Universidad de California San Diego (UCSD), está conduciendo un estudio que busca el identificar y entender mejor las prácticas que fomentan la eficacia en un mismo en las ciencias de estudiantes de diferentes etnidades. Los resultados informarán a los oficiales escolares como pueden ayudar a las estudiantes minoritarias a participar en las ciencias, tecnología, ingeniería, y las matemáticas. Estamos extendiéndolos una invitación a todas las estudiantes del año súper para que participen en el estudio de tan importante.

Las estudiantes que participen tomarán un cuestionario que les preguntará lo que sienten acerca de las ciencias. También ellos tendrán que responder a tres preguntas acerca de su etnicidad, nivel de Educación de los papás y el idioma que más se habla en casa. Algunas de las estudiantes serán invitadas a participar en una entrevista personal. La entrevista consistirá de cinco preguntas donde pregunta que expliquen un poco más en detalle sus sentimientos acerca de las ciencias.

Además, el estudio revisará las calificaciones en ciencias de las estudiantes que participen. Sin embargo, los nombres de las estudiantes nunca serán usados, únicamente se usarán números de identificación para mantener anonimidad.

Nombre del Estudiante

Fecha

Firma del Estudiante

Nombre del padre de familia

Firma del padre de familia

Firma del Investigador

This document has been approved by the Institutional Review Board at California State University San Marcos
Expiration Date: May 14, 2013
California State University San Marcos  IRB Approved Parent consent and Student Assent form to participate in phase 2 (interview) 1 of the research.

Consent/Assent to Participate in Research

Invitation to Participate

Ana Dowey, a student in the joint doctoral program at California State University San Marcos (CSUSM) and University of California, San Diego (UCSD), is conducting a study that seeks to identify and better understand students' interests and attitudes in science. This research will provide valuable information to educators about ways to support students' interest in science, technology, engineering, and mathematics (STEM). Students who volunteer will participate in personal interviews in which they will be asked to provide details about their opinions about girls interested in science and what they believe are practices that foster self-efficacy in science. This interview will take approximately 20 to 30 minutes. With your permission, will be audio taped and transcribed. You will be provided with a transcript of the interview for checking and clarifying any information. You will be able to stop the interview at any time.

If you have any questions about the study, you may direct those to the researcher, Ana Dowey, adowey@csusm.edu, (760)475-7804, or to the researcher's advisor Dr. Katherine Hayden, khayden@csusm.edu, (760)750-8945. Questions about your rights as a research participant should be directed to the IRB at (760) 750-4029.

Student's printed name ___________________________ Date ____________

Student's signature ____________________________

Parent has printed name ___________________________

Parent's Signature ____________________________

Researcher's Signature ____________________________
APPENDIX B

Demographic Questions Included in the Survey Phase of the Study

TOSRA Demographic Questions

Please Tell us about yourself.

1. Which ethnic group do you feel best describes you?
   
   African-American
   
   American Indian or Alaska Native
   
   Asian
   
   Filipino
   
   Hispanic or Latina
   
   Pacific Islander
   
   White (not Hispanic)

2. Do you know the level of your parents educational background?
   
   Both finished High school
   
   One finish high school
   
   Both parents went to college
   
   One parent went to college

3. Is English the main language spoken at home or other?
   
   ____________________________________________
Phase 1: Test of science Related Attitudes TOSRA. Full version as reported by Fraser (1884).

NAME: ___________________________________

Test of Science Related Attitudes (TOSRA) (Fraser, 1981)

Directions:

1. This test contains a number of statements about science. You will be asked what you think about these statements. There are no “right” or “wrong” answers. Your opinion is what is wanted.

2. For each statement, draw a circle around the specific numeric value corresponding to how you feel about each statement.

Please circle only ONE value per statement.

5 = Strongly Agree (SA)

4 = Agree (A)

3 = Uncertain (U)

2 = Disagree (D)

1 = Strongly Disagree (SD)
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<table>
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<tr>
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<tbody>
<tr>
<td>1.</td>
<td>Money spent on science is well worth spending.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>2.</td>
<td>Scientists usually like to go to their laboratories when they have a day off.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
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<tr>
<td>3.</td>
<td>I would prefer to find out why something happens by doing an experiment than be being told.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>4.</td>
<td>I enjoy reading about things that disagree with my previous ideas.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>5.</td>
<td>Science lessons are fun.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
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<tr>
<td>6.</td>
<td>I would like to belong to a science club.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
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<tr>
<td>7.</td>
<td>I would dislike being a scientist after I leave school.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>8.</td>
<td>Science is man’s worst enemy.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>9.</td>
<td>Scientists are about as fit and healthy as other people.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>10.</td>
<td>Doing experiments is not as good as finding out information from teachers.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>11.</td>
<td>I dislike repeating experiments to check that I get the same results.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>12.</td>
<td>I dislike science lessons.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>13.</td>
<td>I get bored when watching science programs on TV at home.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>14.</td>
<td>When I leave school, I would like to work with people who make discoveries in science.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>15.</td>
<td>Public money spent on science in the last few years has been used widely.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>16.</td>
<td>Scientists do not have enough time to spend with their families.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>17.</td>
<td>I would prefer to do experiments rather than to read about them.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>18.</td>
<td>I am curious about the world in which we live.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>19.</td>
<td>School should have more science lessons each week.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>20.</td>
<td>I would like to be given a science book or a piece of science equipment as a present.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>21.</td>
<td>I would dislike a job in a science laboratory after I leave school.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>22.</td>
<td>Scientific discoveries are doing more harm than good.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>23.</td>
<td>Scientists like sports as much as other people do.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>24.</td>
<td>I would rather agree with other people than do an experiment to find out for myself.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>25.</td>
<td>Finding out about new things is unimportant.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>26.</td>
<td>Science lessons bore me.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>27.</td>
<td>I dislike reading books about science during my holidays.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>28.</td>
<td>Working in a science laboratory would be an interesting way to earn a living.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>29.</td>
<td>The government should spend more money on scientific research.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>30.</td>
<td>Scientists are less friendly than other people.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>31.</td>
<td>I would prefer to do my own experiments than to find out information from a teacher.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>32.</td>
<td>I like to listen to people whose opinions are different from mine.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>33.</td>
<td>Science is one of the most interesting school subjects.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>34.</td>
<td>I would like to do science experiments at home.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
</tr>
</tbody>
</table>
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35. A career in science would be dull and boring.  
36. Too many laboratories are being built at the expense of the rest of education.  
37. Scientists can have a normal family life.  
38. I would rather find out things by asking an expert than by doing an experiment.  
39. I find it boring to hear about new ideas.  
40. Science lessons are a waste of time.  
41. Talking to my friends about science after school would be boring.  
42. I would like to teach science when I leave school.  
43. Science helps to make life better.  
44. Scientists do not care about their working conditions.  
45. I would rather solve a problem by doing an experiment than be told the answer.  
46. In science experiments, I like to use new methods which I have not used before.  
47. I really enjoy going to science lessons.  
48. I would enjoy having a job in a science laboratory during my school holidays.  
49. A job as a scientist would be boring.  
50. This country is spending too much money on science.  
51. Scientists are just as interested in art and music as other people are.  
52. It is better to ask a teacher the answer than to find it out by doing experiments.  
53. I am unwilling to change my ideas when evidence shows that the ideas are poor.  
54. The material covered in science lessons is uninteresting.  
55. Listening to talk about science on the radio would be boring.  
56. A job as a scientist would be interesting.  
57. Science can help to make the world a better place in the future.  
58. Few scientists are happily married.  
59. I would prefer to do an experiment on a topic than to read about it in science magazines.  
60. In science experiments, I report unexpected results as well as expected ones.  
61. I look forward to science lessons.  
62. I would enjoy visiting a science museum on the weekend.  
63. I would dislike becoming a scientist because it needs too much education.  
64. Money used on scientific projects is wasted.  
65. If you met a scientist, he/she would probably look like anyone else you might meet.  
66. It is better to be told scientific facts than to find them out from experiments.  
67. I dislike other peoples’ opinions.  
68. I would enjoy school more if there were no science lessons.  
69. I dislike reading newspaper articles about science.  
70. I would like to be a scientist when I leave school.
Phase 2: Phenomenological Phase Student Semi-structure Interview questions

Interview questions

1. In a scale from 0 to 10, with 10 meaning you like it a lot and 0 not at all, how would you rate your interest in science and science related activities?
   Possible probing questions:
   • How does studying science make you feel?
   • Why do you think you feel that way?

2. Has anybody in your family talked about girls liking science or science careers?
   Possible probing question:
   • How do you feel about what they say?

3. Has any of your friends talked about girls liking science or science careers?
   Possible probing question:
   • How do you feel about what they say?

4. How were/are you influenced, or not, by teachers, school environment, and/or counselors about studying science?

5. How were/are you influenced, or not, by your cultural environment (church, youth program, after school programs, social gatherings) about studying science?

6. Do you have any recommendation on what schools or teachers could do to make science more interesting?
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