Fostering Science Identity for Latino High School Students

Ismael Fajardo

A dissertation
submitted in partial fulfillment of the
requirements for the degree of

Doctor of Philosophy

University of Washington
2015

Reading Committee:
Joe Lott, Chair
Eugene Aisenberg
Filiberto Barajas-Lopez
Jason Johnson
Victor Saenz

Program Authorized to Offer Degree:
College of Education

Abstract

High school plays a key role in raising Latino students' science identity. Using the 2009 High School Longitudinal Study (HSLS:09) data from National Center Education Statistics (*n* = 1,658), this study investigates ecological systems influencing Latino students' development of science identity in the ninth grade. Parental involvement in school, peer networks and the science classroom environment was found to have a vital direct and indirect relationship with the development of ninth grade Latinos science identity. The results of this study and their implications are relevant to current policy and practice.

Acknowledgements

First and foremost, I would like to acknowledge and thank my *familia*, Donaciano, Maria, Jaime, Adrian, and Rodrigo, and my wife, Jaime Klippert Fajardo. Each one of you inspires me and I cherish your support and unconditional love. I would also like to thank my colleagues, friends, mentors, the UW Kelly Ethnic Cultural Center, the UW Graduate Opportunities and Minority Achievement Program, the UW Office of Minority Affairs and Diversity, and the American Association of Hispanics in Higher Education for providing me a space to grow personally and professionally. Finally, I want to recognize my supportive and inspiring committee members, Drs. Joe Lott, Eugene Aisenberg, Filiberto Barajas-Lopez, Jason Johnson, and Victor Saenz.

Table of Contents

List of Tables

List of Figures

Chapter 1. Introduction

Statement of the Problem

The demand to meet the rising science, technology, engineering and mathematics (STEM) occupations in the United States has increased scholarly interest in STEM education.[1] The National Science Foundation indicates there are not enough students pursuing employment in STEM careers (i.e., STEM supply) to meet the 21st century STEM demand (NSF, 2013). Scholars claim the lack of STEM supply will hinder America's ability to compete in the global economy, where the marketplace advantage goes to companies that are the first to invent and produce innovative commodities (Anderson & Kim, 2006; Chen & Weko, 2009; Committee on STEM Education National Science and Technology Council, 2013; Lowell & Salzman, 2007; Dowd, Malcom & Bensimon, 2009; National Academies, National Academy of Sciences, National Academy of Engineering & Institute of Medicine, 2010). Carnevale and colleagues argue there will be a shortage in STEM student competencies (e.g., STEM knowledge, skills and abilities) (2011). Student competencies includes knowledge in content domains such as math, chemistry, biology, engineering, as well as skills in processing and problem-solving skills developed within those content domains, and finally then ability to endure and develop personal attributes that influence performance. Researchers continue to examine STEM pipeline trends to understand why potential STEM students and workers

[1] The definition of STEM fields employed by the National Science Foundation includes computer science, mathematics, life sciences, physical sciences, behavioral and social sciences, and health-related fields.

are diverted (Carnevale et al., 2011; Landivar, 2013; Lowell & Salzman, 2007). STEM diversion occurs when there is a lack of STEM interest from top math students, low retention rates in postsecondary education, low STEM representation of minorities and females, low postsecondary to STEM workforce transition, and an excessive STEM employee turnover rate after 10 years (Carnevale et al., 2011). Carnevale and his colleagues suggest that out of 100 students entering a four-year college, only 19 will graduate with a degree in STEM. Of those 19 STEM students, only 10 will work in STEM occupations after college, and eight will continue to work in a STEM career after 10 years (2011). As STEM occupations are expected to grow from 6.8 million to 8 million total jobs by 2018, these statistics support the fact that the STEM pipeline cannot meet current and future demand. Of these STEM occupations, 92 percent will require individuals to have at least some postsecondary education and 65 percent of STEM jobs will require a Bachelor's degree by 2018 (2011). These projections prompt critical STEM discussions on how the United States can maintain economic competitiveness and preserve its direct ties to innovation, economic growth and productivity (Carnevale et al., 2011). Given the importance of the STEM pipeline and its fiscal impact on the U.S., efforts have been made to prepare K-12 students and young adults, specifically historically underserved populations, for careers in STEM. This support has come in the way of sizeable financial investments from non-profit groups, private donors and the federal government (CoSTEM, 2013).

Latinos in STEM

Latinos are the fastest-growing population in the United States population.[2] According to the U.S. Census Bureau data (2010) there are 50.5 million Latinos representing approximately 16.3 percent of the entire U.S. population. Upward trends suggest that the Latino population will constitute a large proportion of the U.S. population by 2040 (U.S. Census Bureau, 2010). Mostly driving this trend is an increase in the Latino school-aged population, coupled with decreases in the Caucasian population in the same age groups. These recent trends are also reflected in changing composition of the U.S. college-age population.

Latinos and the STEM Pipeline

Latinos, both historically and currently are an underrepresented group in the STEM pipeline (Beede, Julian, Khan, Lehrman, McKittrick, Langdon & Doms, 2011). The 2009 U.S. Census Bureau's American Community Survey found that the STEM workforce is largely comprised of Caucasians and males, with the Caucasian population representing 72 percent and males at 76 percent. In 2009, Latinos represented six percent of the STEM workforce, nearly unchanged from the five percent noted in 2000. All females accounted for 24 percent of the STEM workforce, while Latinas were represented at three percent (Beede et al., 2011). Research highlights various STEM pipeline benchmarks that impact the likelihood of Latinos to work in a STEM occupation. For instance, nearly one-third of Latino students do not complete a high school diploma, of those with a diploma, the vast majority do not earn a four-year college degree or beyond (Current Population Survey, 2010). In fact, less than one-sixth (14 percent) of

[2] Latinos will refer to both male and female Latino students unless otherwise specified.

Latinos have a bachelor's degree. Of those Latinos with a bachelor's degree, 17 percent graduated within a STEM major. Of those STEM graduates, only 28 percent of those graduates worked in a STEM-related occupation (Higher Education Research Institution, 2010; Beede et al., 2011). Latino males are three times more likely to pursue STEM degrees than Latina females (Riegle-Crumb and King, 2010). Combined, these STEM pipeline benchmarks have prompted researchers to investigate the conditions that promote or hinder Latino academic achievement in order to meet the STEM workforce demands for this fast-growing population that has historically been under-represented in these fields.

The Significance of High School

STEM research stresses the importance of secondary academic preparation (e.g., high-level math and science course-taking patterns, high-test scores and high school grades) as the most important predictor of earning an undergraduate STEM degree and pursuing a career in STEM (Bonous-Hammarth, 2000; Crisp, Nora & Taggart 2009). Yet, the secondary to postsecondary transition appears to lack academically-prepared students who are ready for the rigor of college-level courses, in particular science. Provasnik and colleagues (2012) provide a report on the Trends in International Mathematics and Science Study (TIMSS) benchmarks and the results indicate that there is a need to closely examine the United States' science pipeline in both the middle and high school settings. TIMSS provided test results on eighth grade science achievement of U.S. students compared to students in other countries around the world.[3] The average science score of U.S. 8th-graders was 525, which is higher than the TIMSS scale average at 500 in 2011.

[3] TIMSS science scale ranges from 0 and 1,000.

These results make the U.S. one of the top education systems in the world. However, twelve other education systems had higher science score averages (e.g., Singapore, Chinese Taipei, Korea, Japan, Finland, Canada, Slovenia, the Russian Federation, and China) with one country scoring as high as 590 for their average. While research continues to highlight the importance of performing well in standardized tests in order to increase students' likelihood to pursue and earn an undergraduate STEM degree (Crisp et al., 2009), TIMMS eighth grade science results indicates that students may be entering high school with lower level science scores compared to other countries (Provasnik, Kastberg, Ferraro, Lemanski, Roey & Jenkins, 2012). Moreover, U.S. postsecondary institutions have seen the effect of these science benchmarks outcomes. In 2013, only 36 percent of high school students were found to be ready for college-level science (ACT, 2013). Differences in science course-taking patterns and science achievement outcomes have been found among gender, racial/ethnic and socioeconomic backgrounds (Lee, 2002; Katsinas & Hardy, 2012). Yet, addressing the secondary science pipeline continues to be a challenge for administrators and educators who attempt to determine best practices for how to academically prepare students in STEM.

Addressing the STEM Pipeline

State science standards have been used since the late 1980s to ensure that students are proficient in science by the time they graduate high school. Science standards were initially developed by the Benchmarks for Science Literacy from the American Association for the Advancement of Science (AAAS) in 1989 and then revamped by the National Science Education Standards from the National Research Council (NRC) in 2011 (NGSS Release, 2013). Most recently, the Next Generation Science Standards

(NGSS) were developed in pace with Common Core State Standards (CCSS) for mathematics, English language arts and literacy (NGSS Release, 2013). NGSS used the NRC K–12 Science Education Framework and received input from science educators, educational experts and the general public from around the country. Twenty-six states also served as lead development partners to create the latest science standards. NGSS has three standard dimensions: content, scientific and engineering practices and crosscutting concepts. These internationally benchmarked standards allow comparisons to be made with other countries that generally score well on the TIMSS. These standards place emphasis on the importance of equitable learning opportunities with the belief that students from diverse backgrounds are capable of engaging in scientific practices that construct meaning in both science classrooms and informal settings (NGSS Release, 2013). NGSS aims to provide the necessary foundation for local decisions around curriculum, assessments and instruction to better prepare high school graduates for the rigors of college and careers, while stimulating and building interest in STEM (NGSS Release, 2013).

The NRC, the NGSS and several scholars have recognized the importance for students to go beyond learning science and the need to focus on vital components not always associated with science achievement (Brown, 2004; Carlone & Johnson, 2007; NGSS, 2013; NRC, 2012). For instance, using identity rather than content knowledge as an analytic lens allows science learning to be viewed as a process of socialization rather than the accumulation of knowledge (Gee, 2000; Brickhouse & Potter, 2001; Brown, 2004; Carlone & Johnson, 2007; Ramsey, 2008). Science identity, a non-cognitive measure, does not solely measure a student's science performance but also their ability to be viewed as a science individual and their confidence in their science ability (Carlone & Johnson, 2007; Sedlacek, 2005).

Previous research finds that students with positive science identities motivate them to persist in their science-learning trajectory, translating into improved student academic behaviors (e.g., going to class, completing homework, organizing class materials, participating in class and studying) and pursuing STEM-related careers (Farrington et al., 2012; Wagstaff, 2014). In addition to academic behaviors, science competence (i.e., confidence in their science ability) increases a student's belief that they can succeed in their science class and are more likely to enroll in advanced science classes (Bandura, 1986; Gilmartin et al., 2006; Jacobs, Davis- Kean, Bleeker, Eccles & Malanchuk, 2005). The completion and submission of science work (e.g., assignments, exams, etc.) is one way to assess their science content knowledge and skills, which provides greater insight into their science performance. As shown by psychological research, the letter grade a student earns has an effect on their attitude about school and about their own science identities, which influences their ensuing behavior and future academic performance (Farrington et al., 2012). Finally, as students begin to feel that they are part of a science community (i.e., science recognition), they are more likely to engage in the science learning process and pursue a career in STEM (Farrington et al., 2012; Ramsey et al., 2013; Wagstaff, 2014).

Purpose of the Study

The STEM pipeline has shown various barriers for Latinos to identify with and succeed in STEM-related careers (Riegle-Crumb, Moore & Ramos-Wada, 2011). As Latinos are the fastest-growing population in the United States, more scholarly attention needs to be given to the development of Latinos' science identity as a way to improve their science-learning trajectories in order to meet the current and future STEM demand. Carlone and Johnson (2007) have found that science performance and competence are necessary for minority women in college to be successful in STEM subjects, but these measures did not solely predict their science identity development. They found a student's science persistence comes from their ability to identify with science as well as being recognized as science individuals (e.g., self and others). Another study, Lu (2013), examined Latino college males pursing a STEM discipline in their first-semester and found that pre-college experiences with teachers, peers and classmates played a significant role in developing a positive science identity (e.g., being recognized as science individuals) before they entered college. The purpose of this study is to extend previous studies by examining Latino students' high school ecological environments and their influence on science identity. By uncovering ecological (e.g., parental, peer, classroom and out-of-classroom) influences and understanding how they interact with one another can facilitate the development of a positive science identity. This study examines ninth grade Latino students' ecological environments and begins to understand how they contribute to their science identity development in high school. The goals of this study are three-fold:

1. Develop a Latino high school science identity measure through a confirmatory factor analysis approach,
2. Uncover ecological (e.g., parental, peer, classroom and out-of-classroom) influences on the development of science identity in the high school context,

3. Understand how multiple ecological domains interact with each another and influence student science identity across a variety of Latino comparison groups.

Significance of the Study

Given the STEM-related achievement disparities for Latino populations, researchers have been tasked to discover ways to promote higher levels of achievement among Latino students who are faced with multiple challenges along the educational pipeline (Gandara & Contreras, 2009; Lopez, 2001; Saenz & Ponjuan, 2009). There is a growing demand to understand the development of science identity in order to increase the ability to purse a STEM career choice and become future scientists (Cobb, 2004; Carlone & Johnson, 2007).

This study focuses exclusively on Latino students, who are largely underrepresented in various STEM-related benchmarks. Existing research tends to focus on the underachievement of Latino students compared to Asian and Caucasian students (May & Chubin, 2003; Walker, 2012). For instance, Gloria and Rodriguez (2000) caution educators not to explain, compare and evaluate Latino students' behaviors and values in relation to those of Caucasian students, as it minimizes Latino students' experiences and relegates Caucasian culture as the referent point. Other scholars have also highlighted the need to focus on Latino students as a stand-alone issue (Saenz & Ponjuan, 2009). There is an immense need to move beyond highlighting the underachievement of Latino students by comparing them to others, and instead begin to understand the dynamics of their academic achievement (Gonzalez & Padilla, 1997; Walker, 2012).

This study aims to expand upon on Latino ninth grade science identity development. Science identity development literature is predominantly qualitative in nature (Aschbacher & Roth, 2010; Brickhouse & Potter, 2001; Brown, 2004; Carlone & Johnson, 2007; Gilmartin & Aschbacher, 2006; Lu, 2013) and focuses on postsecondary settings (Carlone & Johnson, 2007; Espinosa, 2011; Lu, 2013). This study employs a structural equation modeling approach using a recent national dataset in order to provide generalizable quantitative evidence for a science identity construct and to understand the role of ecological factors among Latino high school students.

This research provides an integrated science identity and ecological framework to understand how science identity is influenced across multiple ecological environments and how they interact with one another. Strayhorn (2009) highlights the importance of understanding underrepresented groups across different school settings (e.g., urban, suburban and rural settings) using the Bronfenbrenner Ecological Framework (Bronfenbrenner, 2005). Yet, there are no current studies to date uncovering Latino science educational outcomes across different school settings using an integrated science identity and ecological framework approach.

Finally, these findings contribute to the limited collection of Latino high school STEM research. This dissertation provides implications for how educators can engage Latino students both inside and outside of the classroom, how they can shape curriculum for this student population and how they can prepare them to thrive throughout the science pipeline. Based on these quantitative findings, educators and policy makers are encouraged to seek ways to foster Latino students' science identity early in their secondary experiences by examining ecological influences unique to their own high school populations in order to increase science achievement and science learning trajectories.

Organization of the Study

Chapter two will outline literature from various fields as it relates to this study. The literature review provides an overview of students' secondary science proximal processes such as family, educators, peers, schools and the larger world contributing to the development of Latino students' science identity. Chapter three describes the theoretical frameworks that guide this study. These frameworks include Harper's Anti-Deficit Achievement Theory (2007), Bronfenbrenner's Bioecological Theory of Human Development (2005) and Carlone and Johnson's Science Identity Framework (2007). Combined, these theories aim to explain ecological (i.e., parental, science classroom, peer and out-of-classroom) influences on science identity development. Chapter four provides the research design, data source, data collection and sampling procedures, instruments, analytic sample, measures and analytic approach. This chapter will also describe the limitations of the study. Chapter five provides the results of the study. Finally, chapter six presents a discussion of key findings, implications and directions for future research.

Chapter 2. Literature Review

Introduction

The purpose of this literature review is to summarize parental, peer, classroom and out-of-classroom experiences influencing Latino students' science identity and achievement. Current literature has limited empirical evidence on the role of non-cognitive measures and their relationship to STEM-related academic outcomes for Latino ninth grade students. In addition, multiple ecological environments are rarely examined together. This study attempts to address this gap in current literature by exploring how multiple microsystems and mesosystems play a critical role in shaping students' science identity, thus impacting their science learning trajectories.

The Role of Science Identity

The National Research Council, the Next Generation Science Standards and various scholars have recognized the importance of students to going beyond solely learning science and the need to focus on vital components not always associated with science achievement (Brown, 2004; Carlone & Johnson, 2007; NGSS, 2013; NRC, 2012). Identity development theories have provided educators with ways to understand how students go about discovering their "abilities, aptitude and objectives" while assisting them to achieve their "maximum effectiveness" (American Council on Education, 1937, p. 69). Discovering abilities, goals and success are all a part of creating a sense of identity that allows the student to enter into adult life (Torres et al., 2009). The use of identity, rather than knowledge, as an analytic lens allows science learning to be viewed as a process of socialization rather than the accumulation of knowledge (Gee, 2000; Brickhouse & Potter, 2001; Brown, 2004; Carlone & Johnson, 2007; Ramsey, 2008). Science identity, a non-cognitive measure, does not solely measure a student's science performance, but also measures their ability to be viewed as a science person as well as their confidence in their science ability (Carlone & Johnson, 2007; Sedlacek, 2005).

Many researches and theorists have outlined identity and identity development in similar fashions while isolating different sets of experiences and measures to represent the construct (Carlone & Johnson, 2007; Farrington et al., 2012; Sedlacek, 2005; Wagstaff, 2014). Carlone and Johnson (2007) guide this study through their science identity construct developed for underrepresented, female college students in science. This construct includes three overlapping components: science competence, recognition and performance. In this science identity construct, science identity recognizes the importance of a student's science performance (e.g., graded homework, exams, etc.), science competence (e.g., self-efficacy, academic mindset) and science recognition as a science person, which are not measureable using standardized exams (Carlone & Johnson, 2007; Farrington et al., 2012; Sedlacek, 2005). Extant literature has found how these components are related and impact student-learning outcomes (Aschbacher et al., 2010; Wagstaff, 2014; Kane, 2015). Positive science identities have been found to motivate students to persist in their science-learning trajectory, translating into improved academic behaviors (e.g., going to class, completing homework, organizing class materials, participating in class, and studying) and pursuing a STEM career (Farrington et al., 2012; Wagstaff, 2014). Students who have a positive science competence (i.e., confident in their ability to do well in science) have an increased the belief they can succeed in their science class and are also more likely to enroll in advanced science classes (Bandura, 1986; Gilmartin et al., 2006; Jacobs, Davis- Kean, Bleeker, Eccles & Malanchuk, 2005). Science performance includes those science experiences that can be measured (e.g., completing and submitting student work measuring content knowledge and skills). Finally, as students feel that they are part of a science community (i.e., science recognition), they are more likely to engage in the science learning process and pursue a STEM career (Farrington et al., 2012; Wagstaff, 2014).

According to Gilmartin and colleagues (2006), "Science identity is an evolving construct suggesting that science identity falls along a continuum or multiple continuums that are different for different groups of students with different sets of experiences and contexts (p. 982)." With this in mind, Carlone and Johnson's (2007) Science Identity Framework recognizes other aspects of one's identity, such as race/ethnicity and gender, which also shapes their academic identity. Other studies found that a student's racial identity plays a role in their science interest, motivation, and performance (Aschbacher & Roth, 2010; Walton & Cohen, 2007). For instance, a qualitative study by Aschbacher and Roth (2010) found that being Latina affected their science class experiences, as they felt that teachers often held lower expectations of them because of the racial stereotypes attached to Latinas. In this study, one Latina described that their racial background was "portrayed negatively and devoid of achieving academic goals." These findings are consistent with previous literature highlighting how stereotypes suggest Caucasian and Asian Americans have STEM abilities, whereas Latinos lack intelligence and motivation to be successful in STEM (Sinclair, Hardin & Lowery, 2006; Steele, 1997).

Similar to racial and ethnic stereotypes impacting identities, gender also constrains a female student's choice to pursue STEM-related subjects (Cheryan, Master

& Meltzoff, 2015; Steele, 1997; Steele & Aronson, 1995). Often times parents, teachers and other individuals believe that STEM careers are better-suited for males (Eccles et al., 1990; Sadker & Sadker, 1994). According to Eccles (1983), teachers may contribute to gender differences in motivation by modeling gender role behaviors, communicating different expectations and encouraging different activities and skills for males and females. Previous research has found that females and males typically earn similar grades in science classes, yet females have less positive attitudes toward science, tend to score lower on standardized science tests, engage in fewer science-related activities, enroll in fewer science courses during middle and high school and have lower science college major aspirations in physical science and engineering fields (Catsambis, 1995; Else-Quest et al., 2013; Gilmartin et al., 2006; Pomerantz, Altermatt & Saxon, 2002). Studies also highlight that Latina female students face "double jeopardy" because they encounter race and gender bias in STEM environments (Williams, Phillips & Hall, 2014).

Student Environmental Factors

Academic Preparation

Students' ethnicity, age, gender, language, socio-economic status, family and neighborhood characteristics have been found to influence their academic performance (Farrington et al., 2012). A student's previous test scores, knowledge, experiences in school and academic mindsets are also part of his or her background characteristics (Farrington et al., 2012). Previous research suggests that the strongest factors for entering and succeeding in a STEM major in college includes a student's high school academic preparation, advanced course-taking patterns and attitudes toward science and math in high school (Bonous-Hammarth, 2000; Crisp, et al., 2009; Correll, 2001; Tai, Liu, Maltese & Fan, 2006).

Literature on high school achievement has shown that Latinos often have lower grade point averages compared to other racial and ethnic backgrounds, which limits their college enrollment and their likelihood to pursue a STEM major (Riegle-Crumb, 2006). Furthermore, performing poorly in standardized tests and in advanced science classes has been shown to be a barrier to pursuing postsecondary education for Latinos, including students that have aspirations to pursue a STEM career (Riegle-Crumb, Moore & Ramos-Wada, 2011). When examining the high school to postsecondary transition, only 36 percent of U.S. high school students were found to be ready for college-level science (ACT, 2013). This finding highlights the need to better prepare all students in STEM subjects well before they enter college. A look at the Trends in International Mathematics and Science Study (TIMSS) in 2011, the average science score of U.S. eighth-graders (525) was higher than the average score (500).[4] Although the U.S. was among the top education systems for science, twelve education systems had higher science averages (e.g., Singapore, Chinese Taipei, Korea, Japan, Finland, Canada, Slovenia, the Russian Federation, and China) with one country scoring as high as 590 on average. When closely examining the U.S. eighth grade science scores by race and ethnicity, Latinos scored an average score of 493 (*SE* = 2.4), below the overall United States average of 525. Similar findings are evident with the National Assessment of Educational Progress (NAEP) eighth grade science testing. In 2011, the NAEP reported that eighth grade Latino students scored on average score of 137 out of 300 (*SE* = 0.5), while U.S. students had an

[4] TIMSS science scale ranges from 0 and 1,000.

average science score of 150.[5] In regards to gender, Latina females scored lower on the science test (*M* = 134) compared to Latino males (*M* = 140). While Latino students' average scores have increased over the years (National Center for Education Statistics, 2012), other students (e.g., Asian, Caucasian, two or more races) continue to have higher scores, on average, on all assessments. Research continues to highlight the importance of standardized testing and its impact on earning an undergraduate STEM degree for Latinos (Crisp, Nora & Taggart 2009), yet both the TIMMS and NAEP science exams indicate that Latino students are entering high school with lower scores on science-standardized exams compared to other racial and ethnic groups.

Science Course-taking Patterns

The high school classes that students take are closely related to their academic achievement (Trusty, 2002). That is, the more rigorous courses students take, the more likely students are to do well on standardized tests. According to Connell and Lewis (2003), there is also a direct association between the underrepresentation of students' science course-taking patterns and science-related careers. This advanced science course-taking opportunity gap is highlighted in a study using data from the High School Transcript Study (Nord et al, 2011). They found that Latino high school graduates have lower advanced science participation rates compared to other students. In fact, 30 percent of non-Latino high school students graduate having completed biology, chemistry and physics courses compared to only 23 percent of Latino students. In addition, Latino students are less likely to take advanced placement biology (16 percent vs. 23 percent), chemistry (3 percent vs. 6 percent) and physics (3 percent vs. 6 percent) compared to

[5] The NAEP Science scale ranges from 0 to 300.

other students (Nord et al, 2009). Existing literature highlights that often times Latino students are tracked into low-ability or remedial courses, which consequently limits their access to Advanced Placement courses (Adelman, 2006; Bonous-Hammarth, 2000; Tyson, Lee, Borman & Hanson, 2007). This includes Latino students' that score equal to or better than their Caucasian peers on standardized assessments (Flores, 2007). According to Adelman (2006), Latino students are less likely to attend high schools offering advanced courses compared to Caucasian and Asian American students, which may attribute to fewer opportunities to enroll. These lowered academic expectations, tracking policies and limited opportunities for advanced science courses have left many Latino students unlikely to take subsequent math and science high school and college courses. This may also limit their ability to be successful in courses required for postsecondary admission, even when the majority of Latino students have postsecondary aspirations (Contreras, 2011; Gandara & Contreras, 2009; Zuniga, Olson & Winter, 2005). Murphy, Steele and Gross (2007) argue that the mere fact of having underrepresentation in advanced classes can perpetuate future underrepresentation. These findings suggest that secondary science course taking patterns remain inequitable for Latinos, influencing their decision to enroll in postsecondary education and major in undergraduate science, math and engineering (Brown, 2004).

Student Attitudes

Empirical research has established that a student's attitude toward science can have a significant impact on their science achievement (Beaton, 1996; Chang, Cerna, Han & Saenz, 2008; Eccles, 1983; Leslie, McClure, and Oaxaca, 1998; Singh, Granville & Dika, 2002). A student who has STEM ambition, interest, commitment, expectation, self-concept and self-efficacy is more likely to be successful. Studies suggest that female students are less confident in their science abilities than their male peers (Eccles & Wigfield, 2002). These thoughts result in female students being diverted from STEM-related courses and careers (Pajares, 2005). Research suggests that even when students have comparable academic accomplishments, the difference in confidence still exists among genders (Pajares, 2005; Sadker & Sadker, 1994, Watt, 2006). Cvencek and colleagues (2011) argue that girls begin to retain stereotypes associated with math as early as elementary. Within racial/ethnic backgrounds, several studies have highlighted the importance of psychological factors and the role they play with STEM success among underrepresented minorities (Bensimon & Dowd, 2010; Gloria & Rodriguez, 2000; Leslie, McClure, & Oaxaca, 1998). Latino students participating in STEM-related experiences may perceive their race/ethnic background as inferior, which then decreases the likelihood that they will have success (Brown, 2004). The need to build science identity among Latinos through shaping their perception has shown to be vital to improving their science achievement and learning trajectories.

Parental Environment

Extensive research has found a relationship between parents' background characteristics and students' academic achievement. There is a large body of literature that suggests student achievement and socioeconomic status (measured by parents' education and income) are strongly correlated (Gandara & Contreras, 2009). A family's socioeconomic status (SES) has been found to influence parental involvement and monitoring (Martinez, DeGarmo & Eddy, 2004), a student's academic skills and performance (e.g., Linneham, Weer & Stonely, 2011; Okpala, Okpala, & Smith, 2001;

Morgan, Farkas, Hillemeier & Maczuga, 2009; Sung, Padilla & Silva, 2006) and parental interaction with school staff (Valadez, 2002). Findings continually identify SES as a significant factor that is associated with student academic performance across racial and ethnic groups (Frederickson & Petrides, 2008; Malecki & Demaray, 2006). Having a high parental education level and an occupation in a STEM-related field is an SES factor that has shown to increase a student's likelihood in pursuing a STEM-related major and career (Adelman 2006; Crisp, Nora & Taggart, 2010; Griffith, 2010; Espinosa, 2011; Herrera & Hurtado, 2011). Latino parents, who are more likely to have relatively low levels of formal education, may consequently lack the knowledge of how the U.S. education system works and may not able to assist with schoolwork or pass along any insight regarding education to their children (Gandara & Contreras, 2009, p. 30). Latino parents with limited English proficiency often feel unwelcomed and misunderstood by the educational system and/or have cultural misunderstanding when interacting with the school (Delgado-Gaitan, 1991; Hill & Torres, 2010; Perez & McDonough, 2008). These experiences limit their school involvement that could otherwise improve Latino student outcomes (Henderson & Mapp, 2002). The role of parents as partners in science learning through engagement, support and encouragement needs to be explored in various ecological settings and how they may foster academic achievement and success.

Parental engagement has been shown to promote positive student achievement outcomes, such as earning higher grades, scoring higher on achievement tests, adapting better to school, increasing school attendance, earning more classroom credits, having better social skills and being more likely to graduate high school and continue onto higher education (Catsambis, 2001; Henderson & Mapp, 2002; Hill & Tyson, 2009;

Museus & Vue, 2013). Recent literature continues to find how parents can help their child be successful in science (Ho, 2010; Mena, 2011; Ratelle, Larose, Guay & Senécal, 2005). Parental engagement in science activities includes library and science museum visits (Sun, Bradley, & Akers, 2012), helping with homework, purchasing science books (Perera et al., 2014; Sun et al., 2012), discussing education-related topics (e.g., postsecondary enrollment) with their child (Perna & Titus, 2005; Strayhorn, 2010), contacting the school to volunteer (Perna & Titus, 2005) and initiating contact with the school about academics (Perna & Titus, 2005) have been found to improve student science outcomes. For instance, parental discussions about college were found to be associated with a higher college grade point average for Latino men (Strayhorn, 2010). Familial support has been shown to go beyond the influence of parents, as Latino students' siblings and relatives often serve as role models and vessels for providing college information (Ceja, 2004) that may lead to identifying with STEM-related careers.

In general, parental encouragement and support has been shown to positively impact academic student achievement (e.g., DeWitt et al., 2013; Gilmartin et al., 2006; Gunderson et al., 2012; Mena, 2011; Venezia & Jaeger, 2013). Parental support and encouragement includes a positive attitude towards science, which positively impacts students' science attitudes and interest, postsecondary motivation and aspirations, advanced science course-taking patterns and science exams (DeWitt et al., 2013; Gilmartin et al., 2006; Gunderson et al., 2012; Plunkett & Bámaca-Goméz, 2003; Smith & Hausafus, 1998). Furthermore, one study found that parents who set high academic expectations and create environments that encourage out-of-classroom learning opportunities increased their student's likelihood to be prepared for college (Venezia &

Jaeger, 2013). Conversely, one study found that a lack of STEM support from family is a force that diverts Latina women away from STEM (Valenzuela, 2006). Valenzuela found that Latino families often questioned their daughters' long-term goals of becoming a scientist and also pressured them to contribute to the family over encouraging academic studies (e.g., expectation to contribute financially, provide childcare, and uphold traditional female ideals of marrying and raising a family). Thus, it is vital to understand how parental engagement, support and encouragement influence Latino students' science identity.

Peer Environment

An additional environmental ecological domain, peer interactions, has been shown to impact students' academic outcomes, in particular access and success in science and higher education. Previous studies have found strong associations with peer academic characteristics and students' educational outcomes (Gibson, Gandara & Koyama, 2004; Hanushek, Kain, Markman, and Rivkin, 1999; Woolley et al., 2009). That is, peer influence is predictive of school connectedness, school engagement and placing a higher value on school (Loukas et al., 2006; Garcia-Reid, 2007; Gonzalez & Padilla, 1997). Woolley and colleagues (2009) found peer behaviors (e.g., having friends who often cut class) had a direct impact on Latino students' grades and the time spent on homework. Another study found that peer influence is indirectly connected to school behavior among middle school students (Loukas et al., 2006).

According to Nelson and DeBacker (2008), peers can also influence achievement goals and non-cognitive factors. For example, when peers are linked to a positive climate, exposed to positive science attitudes around high achievement, expose to those considering postsecondary enrollment, and exposed to discussions on jobs and careers, then students were more likely to do well in school. Museus and Vue (2013) had similar findings with Asian American and Pacific Islanders transitioning to postsecondary institutions, in which having peers who valued educational success (i.e., important for friends to attend class, study, get good grades, and go beyond high school, etc.) impacted their grade point average and standardized test scores, as well as their transition to college (i.e., applying and attending college). Other studies have found how peers influence science-related outcomes. Aschbacher and Roth (2010) found how access to networks of knowledge and information contribute to science identity development. However, studies have also found peer support did not impact Latino academic outcomes (DeGarmo & Martinez, 2006; Alfaro, Umaña-Taylor & Bámaca, 2006). This literature overview reveals inconsistent findings with peer influence variables and academic outcomes. Nonetheless, peer influence variables need to be considered to understand their influence on academic outcomes. In particular peer networks should be further explored, as they may be vital in enhancing Latino science identity, and ultimately increasing their STEM participation. Furthermore, literature is limited in understanding peer influences within a science context across different school settings (e.g., urban and rural locations).

Classroom Environment

The literature exploring the classroom setting highlights several important factors that impact student achievement and science identity outcomes. A science teacher's background characteristics (e.g., Bender, 1994; Gilmartin et al., 2006; Gunderson et al., 2012; Russell & Atwater, 2005), teacher-student interactions (e.g., Flores-González, 2002; Hamre & Pianta, 2007; Irvine, 1990), science curriculum (e.g., Lerner, Goodenough, Lynch, Schwartz & Schwartz, 2012; Riegal-Crumb et al., 2010) and students' classroom perceptions (e.g., Gilmartin et al., 2006; Hardré et al, 2007; Museus & Vue, 2013) have been shown to play a significant role in increasing students' science interest, attitudes and achievement.

A science teacher's background characteristics have shown to influence students' learning outcomes. For instance, Bender (1994) observed that students favored the science teaching strategies of their female science teachers in which they talked more often and responded more positively in science class. This study highlights the positive impact female teachers can make on students, however, a higher percentage of female science teachers were found teaching in a school context with a greater proportion of low-performing and low-income students (Gilmartin et al., 2006). These schools were found to be discipline-heavy, had limited science equipment and lacked school-wide support for science education for students.

In addition to gender, a high school teacher's racial and ethnic background has been shown to impact achievement outcomes. Research finds that teachers have the ability to explicitly or implicitly perpetuate the ideology that science is a subject more suited for Caucasian males (Howard & Hammond, 1985; Steele, 1997). That is, a Latino student may internalize feelings of intellectual incompetence in a science area often not perceived as the norm for Latino inclusion (Howard & Hammond, 1985; Steele, 1997). Furthermore, a teacher's attitude toward students as science learners can affect a student's perception of their abilities and interest in science (Gilmartin et al., 2006; Singh et al., 2002). Another background characteristic is a teacher's teaching experience. Their experience and the quality of their training is correlated with student's academic achievement (Gimbert, Bol & Wallace, 2007). Russell and Atwater (2005) found that teaching inexperience has a profound effect on student motivation, attitude and interest in continuing in the science pipeline. Moreover, students attending predominantly Latino schools are twice as likely to be taught by teachers with three years of teaching experience or less, compared with those attending predominantly Caucasian schools who had more experience on average (Darling-Hammond, 2000; Flores, 2007; Rumberger & Thomas, 2000).

A number of studies have shown that positive teacher-student interactions improve outcomes, both for teachers and students. A positive classroom environment between a teacher and their students has been associated with teachers having higher expectations of their students (Irvine, 1990), students developing positive academic identities (Flores-González, 2002), students improving their self-concept and academic engagement (Fraser & Walberg, 1991), students increasing their motivation to do well (Irvine, 1990) and students having higher levels of science identity (Gilmartin et al., 2006, 2007). Woolley, Kol, and Bowen (2009) found that students' overall school satisfaction weighed upon if they felt supported by their teacher. Feeling supported led to improved grades and time spent on homework. Studies have found that teachers who teach advanced-level classes (e.g., Advanced Placement) tend to have more positive interactions with their students compared to teachers of lower-level classes (Oakes & Wells, 1998; Wheelock, 1992). Irvin found that African American students who experience acceptance, encouragement and understanding from their teachers are more likely to have positive relationships with their teachers (1990). Given the above, there is a need to further examine teacher-student interactions and their influence on science identity.

Student's perceptions of their classroom have been shown to impact learning outcomes (Fraser, 1991; Museus & Vue, 2013), which is particularly true among underrepresented students who are less likely to pursue STEM-related occupations (Baker, 1999). For example, a student's perception of a supportive, orderly and positive classroom environment was found to be strongly associated with positive academic achievement (Fraser, 1991; Museus & Vue, 2013). Stout, Dasgupta, Hunsinger and McManus (2011) found that women develop stronger STEM identities through exposure to positive cues in their academic surroundings. Gilmartin and colleagues (2006) provide examples of teacher cues, such as "My teacher thinks I could be a good scientist one day," "My teacher has high expectations of me," "I know as much about the content of this class as other students do," "My teacher cares if I think science is interesting," and "My teacher cares if I learn science." Another study found students' perceptions of supportive teacher behaviors and beliefs positively influenced their perceived ability and positively impacted their learning goals and outcomes (Hardré et al, 2007).

Another study, Museus and Vue (2013), had similar findings among Asian Americans and Pacific Islanders transitioning to college, in which teacher quality (i.e., a teacher who praises effort, a teacher who expects student success in school, a teacher who is interested in their students, etc.) impacted grade point averages and standardized test scores. Ramsey, Betz and Sekaquaptewa (2013) highlight the importance of women receiving welcoming messages in their STEM academic environment. In their college study, they found that these women were more likely to be proud of being a STEM majors and were more likely to have peer role models. They concluded that when female stereotyping and STEM stereotyping were minimized, it increased Latinas' ability to identify with STEM fields. However, there is a shortage of research discussing high school students' science classroom perceptions of their academic environments.

Out-of-class Science Environment

Out-of-class science experiences are also of interest to scholars because of their potential to engage groups who have historically been underrepresented in STEM disciplines (Dierking, Falk, Rennie, Anderson & Ellenbogen, 2003; NRC, 2009; NGSS, 2013; Wagstaff, 2014). An out-of-classroom science experience includes informal settings such as museums, parks, zoos and planetariums (NRC, 2009). These experiences often provide an applied learning experience working with resources and the chance to interact with scientists that the traditional classroom may not offer (McComas, 2006). Studies have found that student participation in out-of-class science activities increases student educational outcomes such as having higher science achievement, positive attitudes, interest and understanding of science, academic aspirations, positive science identity, self-esteem, determination and college preparation (Cole, 2012; Darling, Caldwell & Smith, 2005; Gilmartin et al, 2006; Szechter & Carey, 2009; Venezia & Jaeger, 2013). These experiences provide students a safe place to explore a STEM-related field, allowing them to gain scientific skills and envision themselves as a future scientist (Crane, Thiry & Laursen, 2011). In fact, out-of-classroom science learning opportunities have shown to better serve underrepresented STEM groups in their ability to target their interest by drawing on their cultural practices (NRC, 2009). Crowley and colleagues (2001) found that parents were more likely to provide an explanation to boys than they were to girls at a science museum. Out-of-classroom science experiences promote positive science-related outcomes, thus this study will further examine these experiences and their influence on science identity for Latino students across multiple contexts.

High School Environment

Literature on high school location showcases differences in various student outcomes. For instance, students attending private schools tend to score higher in eighth grade NAEP science measures than do those in public schools (NAEP, 2011); suburban schools tend to academically outperform urban schools (Harper, 2015; Strayhorn, 2009); and male students often benefit academically when they live in suburban neighborhoods (Ensminger, Lamkin & Jacobson, 1996). In fact, Harper (2015) argues that the majority of published literature on urban high school in the United States focuses on problems of inadequacy, instability, underperformance and violence. The majority of these studies also tend to focus on one specific school setting when investigating student outcomes (e.g., Hondo, Gardiner & Sapien, 2008; Roderick, 2003; Thomas & Stevenson, 2009; Zhou, 2003). For instance, Hondo et al (2008) examined Latino students attending rural schools in Idaho and found that students felt invalidated and invisible leading them to feel marginalized. These researchers provide evidence that these rural schools lacked cultural responsiveness in school curriculum, instruction, policies and practices. This environment can leave marginalized students questioning the value or necessity for education, and in extreme circumstance lead to students dropping out. Although this work showcases the importance of Latinos and their rural experiences, the literature could benefit from determining if rural Latino experiences are unique only to rural settings or if they are similar to Latino experiences across urban and suburban settings. Studies have begun to showcase these differences across multiple settings, whereas Strayhorn (2009) found Black male students in suburban schools had higher aspirations than those students attending urban schools and the differences were even more pronounced between Black males in suburban and rural contexts (p. 723). Given differences in educational outcomes by different school locations, there is a need to examine Latino science experiences between urban, suburban and rural schools.

Chapter 3. Conceptual Framework

Introduction

To provide a theoretical background for understanding Latino students' science identity development, this chapter describes three theoretical approaches: Harper's Anti-Deficit Achievement Theory (2007), Bronfenbrenner's Bioecological Theory of Human Development (2005) and Carlone and Johnson's Science Identity Framework (2007). Combined, these theories aim to explain how ecological microsystem (i.e., parental, science classroom, peer and out-of-classroom) influences impact students' science identity development and understand how these influences differ between gender, science enrollment and school location.

Anti-deficit Achievement Theory

The shortage of STEM students across the United States has been the reason for STEM's fast rise in popularity among research and policy decisions. Harper (2010) highlights that most policy reports and published research on students of color in STEM, in particular African Americans and Latinos, intensifies their failures and deficits (e.g., low high school academic preparation) instead of their successes and achievements.[6] Harper subsequently discourages deficit framing and encourages a move toward asset-based theories in order to advance the study of achievement by students of color. Harper (2007) describes an Anti-deficit Achievement Theory as an approach to provide a framework for understanding students of color and how they navigate educational settings, despite the deficit discourse surrounding them.

---

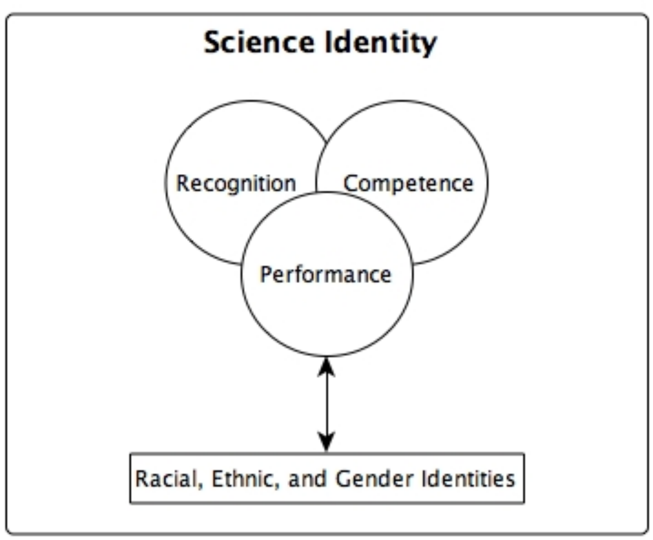
[6] Students of color refer to racial and ethnic minority groups (e.g., Latinos, Black/African American, Native Americans, and Pacific Islanders).

This Anti-deficit Achievement Theory builds on the work of Bensimon's (2005) Deficit Cognitive Frame, by countering deficit characteristics associated with the culture of the disenfranchised, discourses that continue to blame students' background (e.g., lack of preparation, motivation, etc.) and strategies that focus on fixing students (e.g., remedial courses). Harper argues that researchers and institutions should aim to learn from minority students who have chosen to make the most of educational institutions, both inside and outside of the classroom. Harper's theoretical perspective is grounded on investigating Black males that are active learners who have high grade point averages, are involved in leadership and engagement, have more social capital at the end of high school or college than when they began, and have helpful institutional agents and supporters. He believes that this anti-deficit approach can provide institutions with the conditions and factors necessary for these students to be successful. His research is focused on Black college students, but this framework can also be applied to Latino students. Harper (2010) demonstrates how research questions should be framed as asset-based questions. For example, instead of using a deficit-oriented question such as, "Why are Latinos underprepared for college-level science courses?" Harper's theoretical approach reframes this question to "How do STEM achievers from low-resource high schools transcend academic unpreparedness and previous educational disadvantages?" Using this theoretical lens as a first step, this study will focus specifically on Latino ninth grade students' secondary environment and examine the relationship between their environmental settings' and science identity.

Science Identity Framework

Science identity refers to how an individual's personality is formed in a particular stage of life (Gee, 2000). The use of science identity as an outcome variable allows for the investigation of students within an educational ecological environment contributing to their science learning trajectories. Research suggests that non-cognitive developmental factors, such as science identity, play an instrumental role in their science trajectories (Supple et al, 2006; Carlone & Johnson, 2007; Walton & Cohen, 2007). Carlone and Johnson (2007) found that students' persistence in a particular subject (e.g., science, math, etc.) comes from their ability to identify with a given subject and with the possible careers related to that subject. Studies have found that a combination of environments, including home, school and co-curricular activities (e.g., counseling, science courses, classroom perceptions, peer academic attitudes and family engagement support) impact students' perceptions of their abilities, career options and expected success, all of which shape their science identities (Aschbacher & Roth, 2010; Gilmartin & Aschbacher, 2006).

Figure 1. Johnson and Carlone (2007) Model of Science Identity



Carlone and Johnson's Science Identity Framework allows this study to explore Latinos ninth grade science identity by applying a conceptual framework composed of three overlapping science components: science competence, recognition and performance (Carlone & Johnson, 2007). Science competence refers to a student's perceived grasp of scientific concepts and material. Science performance typically pertains to those scientific experiences that can be measured. Science recognition refers to a student's ability to be recognized as a legitimate scientist by reputable members of the scientific community, such as a teacher, faculty or an individual in a STEM occupation. In their research, Carlone and Johnson found recognition as the most salient factor in developing and solidifying a science identity for women of color in postsecondary settings (2007). Another study, Lu (2013), uses Carlone and Johnson's Science Identity Framework to examine Latino males pursing a STEM discipline in college and found that pre-college experiences with teachers, peers and classmates played a significant role in developing a positive science identity (e.g., recognized them as science and math people). This theory fits the scope and purpose of this study because it provides an understanding of science identity development for an underrepresented group, Latinos, in a high school setting before they enter postsecondary education.

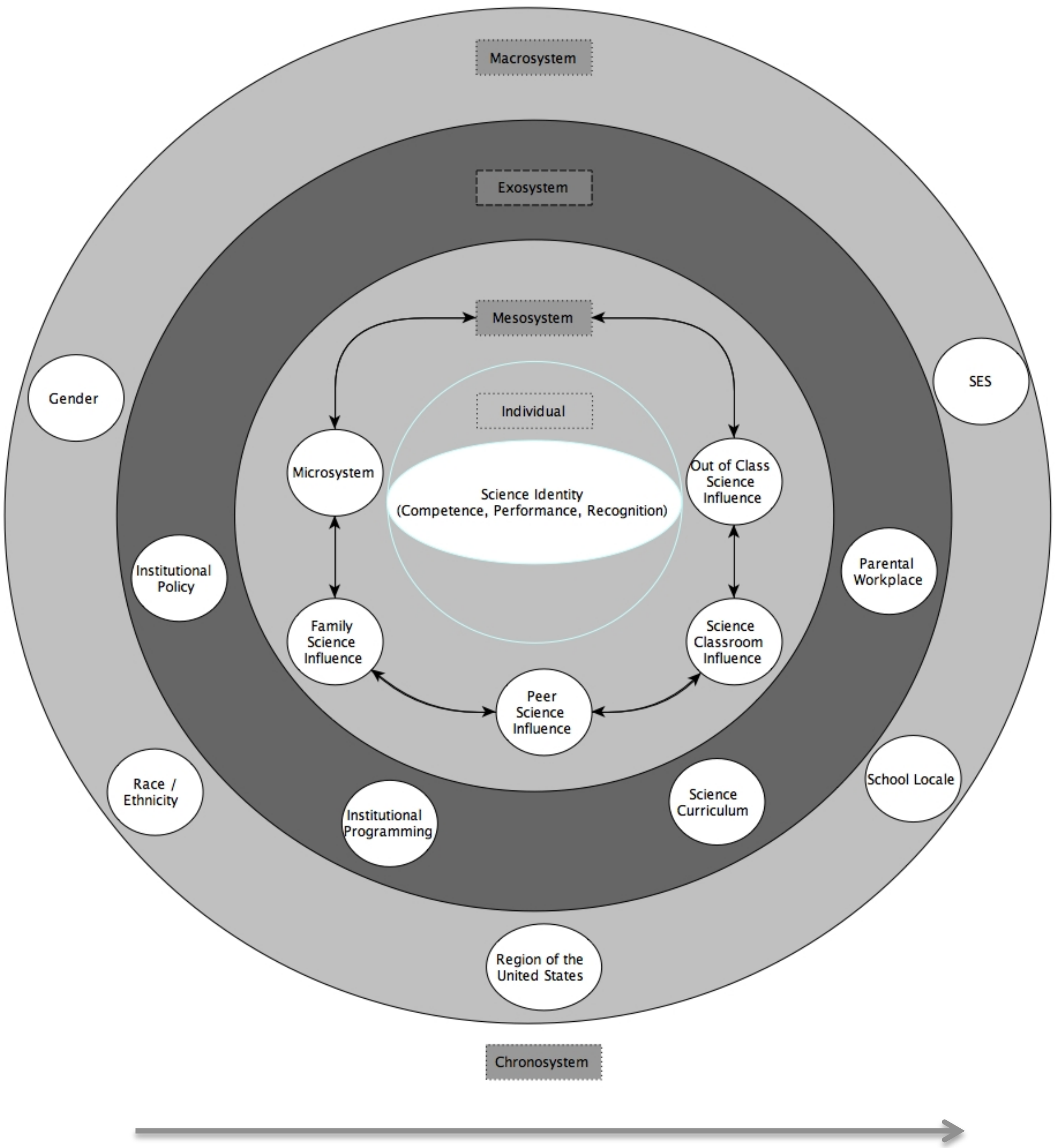
Bioecological Theory of Human Development

The final framework guiding this study is Bronfenbrenner's (2005) Bioecological Theory of Human Development. Ecological models have been shown to effectively identify the peers, teachers and social environments that develop students' engagement choices and experiences (Nasir, Jones & McGlaughlin, 2011). Ecological theories have emerged from multiple areas of study, including campus ecology, developmental ecology and human ecology (Evans et al, 2010). Of importance to this study is the consideration of proximal processes between individuals and cultural influences (e.g., beliefs, customs, skills of the culture, etc.) (Evans et al., 2010). Scholars have predominantly relied on the work of developmental psychologist, Urie Bronfenbrenner (1979, 1993 & 1995), an innovator in this area. He argued that ecology research involves artificial, unfamiliar and brief situations that are not easy to generalize to other settings, and that "human environments…are so complex in their basic organization that they are not likely to be captured…through simplistic unidimensional research models that make no provision for assessing ecological structure and variation" (Bronfenbrenner, 1979, p. 514). Bronfenbrenner's ecology model provides this study with the flexibility to consider the developmental context of various student learners (e.g., different racial/ethnic backgrounds, genders, etc.) and their environmental interactions.

Bronfenbrenner and Morris (2006) outlined the evolution of the Ecological Systems Theory model over the past four decades. In the latest model, the Bioecological Theory of Human Development was defined as, "The scientific study of the progressive, mutual accommodation, throughout the life course, between an active, growing human being and the changing properties of the immediate settings in which the developing person lives, as this process is affected by the relations between these settings, and by the larger contexts in which the settings are embedded" (Bronfenbrenner, 2005, p. 107). Bronfenbrenner's (2005) Bioecological Model presents two main propositions as a critical distinction between environment and process. The first proposition centers on the experiences of the individual, in which student development occurs within reciprocal interactions between human organisms, objects and symbols in its immediate external environment throughout the life course of the individual (Bronfenbrenner & Morris, 1998). To be effective, interactions must occur on a fairly regular basis over extended periods of time, called proximal processes (Bronfenbrenner, 2005). The second proposition describes, “A developmental outcome at a later point in time is a joint function of a process; characteristics of the developing person; the nature of the immediate environmental context in which the person lives; and of the length and frequency of the time interval during which the developing person has been exposed to the environmental setting under consideration” (Bronfenbrenner & Evans, 2000, p.119). Together, Bronfenbrenner’s propositions act as a driving force in the model, offering four main components, process-person-context-time (PPCT model), and how they interact with each other (2005). Bronfenbrenner describes five nested systems of sociocultural development that consists of microsystem, mesosystem, exosystem, macrosystem and chronosystem in the Bioecological Model (See figure 2). Each system contains roles, norms and rules that shape an individual’s development (Bronfenbrenner, 2005). Together, Bronfenbrenner’s five systems and Carlone and Johnsons (2007) Science Identity Framework embody a network of interactions that reflect an individual’s ecology.

Figure 2: Integrated Science Identity Model

(Adaptation of Bronfenbrenner and Carlone and Johnson Frameworks)



The two interlayers, microsystems and mesosystem have direct influence on a student. The first system, microsystem, is a "pattern of activities, social roles and interpersonal relations experienced by the developing person in a given face-to-face setting with particular physical, social and symbolic features that invite, permit or inhibit engagement in sustained, progressively more complex interactions with, and activity in, the immediate environment" (Bronfenbrenner, 1994, p. 39). A microsystem is the first point of interaction between individuals and environments. Microsystem variables include family, school, teacher and peer interactions. The second system is called a mesosystem. Bronfenbrenner (1993) describes this as "Linkages and processes that take place between two or more microsystem settings containing the developing person. Particular attention is focused on the synergistic effects created by the interaction of developmentally instigative or inhibitory features and processes present in each setting" (p. 22). Microsystems influence the overall mesosystem. Within a high school setting, a mesosystem can be created between a science teacher and parent microsystems. For example, during parent-teacher conferences, a teacher may tell a parent that their child is receiving high grades in science and urge the parent to enroll their child in out-of-class science activities to learn about rockets at science camp or visit a science museum. Together, this mesosystem can potentially contribute to the student's developmental opportunities, in this case, in the subject of science.

Exosystem, macrosystem and chronosystem are the third, fourth and final systems. According to Bronfenbrenner (1994), exosystem comprises the linkages and processes taking place between two or more settings, at least one of which does not contain the developing person, but in which events occur that indirectly influence processes within the immediate setting in which the developing person lives (p. 40). Previous research on exosystems looked at areas that have the potential to influence students indirectly, including the parents' workplace, family social networks and community peer groups (Renn, 2003). More recent exosystem research has focused on examining school policies (Basham, Maya & Maynard, 2010). An exosystem can provide opportunities to examine STEM policy at the district and state level and its indirect influence on student STEM development such as requiring state exams to measure students' science performance in order to receive federal or state funding. The fourth system is the macrosystem, and this consists of a pattern of relationships between the previous three systems shaping "Belief systems, bodies of knowledge, material resources, customs, lifestyles, opportunity structures, hazards and life course options that are embedded in each of these broader systems" (Bronfenbrenner, 1994, p. 47). Gender, race/ethnicity, age, cultural and societal values, health and laws are all part of the macrosystem (Bronfenbrenner, 2005; Evans et al., 2010; Basham et al., 2010). Basham and colleagues (2010) further argue that social, cultural, political and economic objectives drive the educational priorities related to STEM. The exosystem and macrosystem have an indirect relationship with the student's life, but they are also a powerful influence on the student's socialization (Bronfenbrenner & Morris, 2006). The final system is the chronosystem. This system focuses on the interaction over time between the characteristics of the person and the environment in which they live (Bronfenbrenner, 2005, 1994). In other words, this system is all that a student experiences, which must be acknowledged and validated (e.g., historical events in a broader context, major life transitions). Bronfenbrenner argues that even though time changes, there are relationships in the model that remain constant and have specific defining properties (Bronfenbrenner, 2005). Together, this theoretical model allows for the exploration of Latino students' proximal processes within systems relating to students' science identity development. Therefore, this study will examine interactions between individuals and their environment. A major strength to this framework is the ability for researchers to consider as many theoretically relevant environmental variables as possible, rather than attempting to isolate one variable at a time by controlling for all other variables. This Latino ecological model aims to help explain how the outcome occurs as an interaction of person and environment by describing the process of development using five systems of influence; the micro-, meso-, exo-, macro-, and chronosystems (Bronfenbrenner, 1994; Evans et al., 2010).

Harper's Anti-Deficit Achievement Theory, Carlone and Johnson's Science Identity, and Bronfenbrenner's Bioecological Theory of Human Development Model guide this study. Together, these frameworks will help to explain the impact of hypothesized influences on ninth grade Latinos' science identity. Science identity is comprised of three overlapping components: 1) science competence, 2) science recognition, and 3) science performance A student's ecological system includes many systems of influence, of particular importance to this research design are the two innermost layers of the model: microsystems and mesosystems. The microsystems centered around science identity development include the student, peer, parental and science classroom influences. Student mesosystems will be examined to determine the extent to which they have influence on the microsystems. The exosystem and macrosystem do not directly involve the Latino student, but rather influence their day-to-day experiences indirectly and therefore is beyond the scope of this study.

Research Questions

Three specific research questions guide this study:

1. How does the hypothesized science identity model fit with the data?

2. What are the direct, indirect and total effects of Latino student background, parental school-based involvement, peer influence, science classroom influence and out-of-classroom science influence on science identity development?
3. Do the parameters of the science identity model vary across different learning contexts (i.e., gender, science class enrollment and school location)?
    a. If so, what are the direct, indirect and total effects?

Hypotheses

Given the limited empirical knowledge on the relationship between ecological microsystems and Latino science identity development, this study tests for multiple hypotheses. First, Carlone and Johnson's Science Identity and Bronfenbrenner Theory of Human Behavior Framework will provide an adequate fit to the HSLS:09 data. That is, the initial measurement model for this study proposes that parental, science classroom, peers and out-of-classroom interactions will have a direct, indirect and total effect on a Latinos' ninth grade science identity development. Second, there will be direct and indirect effects between parental, science classroom, peers and out-of-class interactions on the development of Latinos' ninth grade science identity. Previous research has found that students' face-to-face interactions and support from family members and peers are among the most common and important proximal processes for students regarding their academic outcomes (Muss, 1996). Research has found teachers are also important in distal trajectories of students (Wong & Rowley, 2001). This study hypothesizes that parental, peer and science classroom influences will have the most impact on Latino science identity, and that out-of-classroom will have the least amount of impact due to reduced opportunities for direct interactions. The greatest impact will occur with peer influences, as peer behaviors have been found to have a direct impact on Latino students' academic outcomes, such as grades and time spent on homework (Woolley et al., 2009).

Third, the science identity model parameters will vary across hypothesized comparison groups (gender, science enrollment and school location). There will be parental, peer, classroom and out-of-classroom ecological differences within the gender comparison model. Parental influence will have a greater impact on female students' science identity compared to male students. Valenzuela found that Latino families doubted their daughters' long-term goals of becoming a scientist and pressured them to contribute to the family (e.g., via earning money, providing childcare and upholding traditional female ideals of marrying and raising a family). In addition, Gibson et al. (2004) concluded that Latino ninth grade males are pressured to engage in risky behaviors at higher rates compared to female students. Engaging in these risky behaviors can lead students to being reprimanded (e.g., suspended or expelled), thus decreasing their likelihood of academic success (Bahena, Cooc & Currie-Rubin, 2012; Li, Lynch, Kalvin, Liu & Lerner, 2011). Other research finds that positive peer behaviors can also influence students' academic achievement (Stanton-Salazar, 2001). Therefore, it is hypothesized that male peer influence will have a greater effect on science identity compared to female students. Research finds that teachers may contribute to gender differences in motivation by modeling gender role behaviors, communicating different expectations and encouraging different activities and skills for males and female (Eccles, 1983). Roorda, Koomen, Split and Oort (2011) discovered that increased teacher support leads to higher levels of achievement for females compared to males. Furthermore, Stout, Dasgupta, Hunsinger, and McManus (2011) found that female students develop stronger

STEM identities through exposure to positive cues in their academic surroundings. Finally, out-of-classroom science interactions will have the least amount of impact on science identity for both males and female students. Yet, female students will have lower impact compared to male students as research has found that boys are more likely to receive an explanation at science museums from parents than girls (Crowley et al., 2001).

Within the science enrollment models, Latinos enrolled in advanced science classes will have increased parental, peer and out-of-classroom influences on their science identity development compared to Latinos who are enrolled in regular science. Research has found that teachers leading advanced-level classes (e.g., Advanced Placement) tend to have more positive interactions with their students compared to teachers of lower-level classes (Oakes & Wells, 1998; Wheelock, 1992). In addition, several studies have found differences in student outcomes based on school characteristics (e.g., Harper, 2015; Strayhorn, 2009). Within the school location comparison model, it is hypothesized Latino students located in the suburbs will have higher science identities compared to those in urban and rural/town locations. Strayhorn found that students located in suburban schools had increased academic aspirations compared to those students attending urban and rural schools (2009). Research finds that almost 50 percent of urban Latino high school students report being influenced by other students in school (Gibson, Gandara & Koyama, 2004). Therefore, urban peers will have a greater positive effect on Latino science identity compared to peer influences in other locations. Parental influence will have a greater positive impact on Latino students attending suburban schools compared to students attending urban and rural/town schools. Out-of-classroom influence is greater on Latinos' science identity in the urban and suburban settings compared to students in rural/town locations. Urban classroom influence will have a greater impact on science identity compared to suburban and rural/town science classroom settings.

Chapter 4. Methodology

Introduction

Given the goals of this study, data collected from the High School Longitudinal Study of 2009 is examined to identify the relationship between ecological factors and ninth grade Latino science identity. This chapter provides the research design, data source, data collection, sampling procedures, instruments, analytic sample, measures and analytic approach used in this study.

Data Source

The High School Longitudinal Study of 2009 (HSLS:09) was conducted by the National Center for Education Statistics (NCES) of the Institute of Education Science (IES), United States Department of Education, with additional support from the National Science Foundation (Ingels, Pratt, Herget, Burns, Dever, Ottem, Rogers, Jin, and Leinwand, 2011). The HSLS:09 is the fifth study under the NCES Secondary Longitudinal Studies program. The previous four completed studies include the National Longitudinal Study of the High School Class of 1972 (NLS:72), the High School and Beyond (HS&B) Longitudinal Study of 1980, the National Education Longitudinal Study of 1988 (NELS:88) and the Education Longitudinal Study of 2002 (ELS:2002). Together, these longitudinal studies collected information on student and institutional educational experiences along the pipeline covering over four decades from the 1970s through the 2000s. HSLS:09 is designed to place additional emphasis on STEM student experiences and their high school to career trajectories. This study uses HSLS:09 public available data obtained through the NCES website. This data has been coded, aggregated, or altered to mask individually identifiable information (Ingels et al., 2011).

Data Sampling and Collection Procedures

The HSLS:09 recruited schools one year before data collection began (Ingels et al., 2011). HSLS:09 used a two-stage random sample design with primary sampling units defined as schools selected in the first stage, and students randomly selected from the sampled schools in the second stage (Ingels & Dalton, 2013). The first stage used school type as the target population in stratum one. Schools fell within three categories, regular public and public charter schools, Catholic schools and other private schools. The second stratum examined the school types by targeting geographic regions in the United States. Regions consisted of Midwest, Northeast, South and West. The Midwest region comprised of twelve states: Iowa, Illinois, Indiana, Kansas, Michigan, Minnesota, Missouri, North Dakota, Nebraska, Ohio, South Dakota and Wisconsin. The Northeast region included nine states: Connecticut, Delaware, Massachusetts, Maine, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island and Vermont. The South region included sixteen states: Alabama, Arkansas, District of Columbia, Florida, Georgia, Kentucky, Louisiana, Maryland, Mississippi, North Carolina, Oklahoma, South Carolina, Tennessee, Texas, Virginia and West Virginia. The West region included thirteen states: Alaska, Arizona, California, Colorado, Hawaii, Idaho, Montana, New Mexico, Nevada, Oregon, Utah, Washington and Wyoming. The final stratum in the first stage involved the schools' locale (i.e., city, suburban, rural, and town). Together, these stratums identified 1,889 eligible schools and a minimum of 800 schools was needed to yield a sufficient nationally representative sample (Ingles et al, 2011). Given the above, a total of 944 of 1,889 eligible schools participated in the base-year. In total, the base-year accounted for 767 public schools and 177 private schools. Of these schools, 149 are located in the Northeast, 251 in the Midwest, 380 in the South and 164 in the West. The majority of these schools were located in suburban areas (335 schools), followed by urban areas (272 schools), rural areas (220 schools) and towns (117 schools).

The second sampling stage consisted of 26,305 eligible students from the randomly selected 944 participating schools in the base-year. To meet the HSLS:09 analytic goals, a minimum of twenty and a maximum of thirty-eight ninth grade students were selected from each of the 944 participating schools to the meet the stratum-specific sampling rates. An average of 28 students per participating school were sampled. Students were then randomly selected using a stratified systematic sampling procedure from base-year enrollment lists provided by administrative contacts at the school (Ingels & Dalton, 2013). The second-stage sampling stratum was defined by the students' racial and ethnic backgrounds (Hispanic, Asian, Black, and Other) as specified by the school.

Once the sampling procedures were completed, HSLS base-year data collection consisted of students, parents, administrators, counselors and math and science teachers using an in-school session (computerized or self-administered) or an out-of-school session (telephone interview) from September 2009 through April 2010. To achieve this, the HSLS identified a school coordinator at each school to serve as a contact between the school and HSLS. This school coordinator was responsible for establishing a "survey day" to provide an in-school computerized administration of the survey to the schools' sample of students. To ensure a secure and controlled testing environment, Sojourn hardware was used with school computers and/or HSLS laptops. The school coordinator prepared the survey and identified the appropriate administrator and counselor at their school to complete the surveys. Administrators, counselors, math and science teachers and parents were given the option to complete the survey by web-based self-administration or telephone-computerized administration.

Survey Instruments

HSLS:09 collects data from various individuals (e.g., students, parents, math and science teachers, administrators and counselors); however, the HSLS:09 theoretical framework takes the student as the fundamental unit of analysis. That is, the student file contains one record per student, and all associated data is merged at the student level. In particular, this study will focus on the cross-sectional nature of the survey and focus on student and parent surveys in 2009.

Student Survey

The 90-minute in-school student survey consisted of 15 minutes for instructions and setup, 35 minutes for the student survey and 40 minutes for a 40-question adaptive algebraic reasoning assessment. The student survey covered student demographic information (section A), previous school experiences (section B), math and science experiences (section C and D), home and school (section E), plans for postsecondary education (section F) and life after high school (section G). Students were randomly assigned to one of two groups, which determined the order in which these sections were administered. Half of the students completed the sections in alphabetical order from Section A to Section I. The other half were administered sections in the following order: A, B, C, D, E, H, G, F and I. Sections F and H were swapped to balance item non-response for students who were unable to complete the entire survey during the full-length in-school session. Similarly, Sections D and E were reordered to ensure that when the in-school session was shortened, roughly the same number of students would be administered the questions in each section.

Among survey-eligible students (n = 24,658), 21,444 ninth grade students completed the survey. The majority of surveys were completed during in-school sessions (98 percent), compared to those completed outside of school (2 percent). Of these ninth grade students, males accounted for 10,887 and females accounted for 10,557 of the sample. Within race/ethnicity, the sample consists of 223 American Indian/Alaska Native students, 2,144 Asian/Pacific Islander students, 2,684 Black or African American students, 3,516 Hispanic students, 12,630 Caucasian students, and 247 considered Other-race students, more than one race students, or a missing value.

Parent Survey

The parent survey sampled the parent or guardian most knowledgeable about his or her child's educational experience. The survey collected information about family structure (Section A), family's origin and language (Section B), parent's education and occupation (Section C), previous educational experiences (Section D), parent's involvement (E) and the ninth grader's future (Section F). Parents had the option to complete the survey by either a computer-assisted telephone interview or a web-based, self-administered survey. The survey took approximately 30 minutes to complete.

Of the 25,206 eligible parents, a total of 16,995 completed the survey. Standard computer assisted telephone interviews (including partial interviews) accounted for 94 percent of the completed surveys, abbreviated interviews accounted for 1 percent, and 5 percent were paper-and-pencil completed interviews. For parents using the computer-assisted telephone interview, bilingual interviewers were trained to administer the

Spanish version of the survey over the telephone (Ingles et al., 2011). Parents were able to toggle between the English and Spanish versions as needed. Approximately 6 percent of parents completed interviews in Spanish (n = 936 parents).

Analytic Sample

This study centers on ninth grade students self-identifying as Hispanic, Latino or Latina attending public and private high schools in the United States. This subsample consists of 3,516 ninth grade Latinos who were drawn from a larger data set that included 21,444 students from 2009. Given the goals of this study to include both Latino student and parent surveys. A combination of Latino students, parents and their item responses produced a final analytic sample with complete data (1,658 student respondents with parent data). Latino males accounted for 48 percent (n = 800) and females accounted for 52 percent (n = 858) of the subsample. Moreover, 32 percent of these students attended schools located in urban areas (n = 522 students), 39 percent in suburban areas (n = 643 students) and 30 percent in rural/town areas (n = 493 students).

Measures

Dependent Variable

Carlone and Johnson's (2007) Science Identity Framework provides a lens for selecting possible variables to measure students' science identity. The Latino ninth grade science identity latent construct is represented by three measurable variables using seven items.

Table 1. Science Identity Definitions and Coding Schemes

Latent Variable	**Measured Variable**	Variable Coding
Science Identity		
	Science recognition	Two-item composite: (1) ninth grader sees himself/herself as a science person, and (2) others see ninth grader as a science person on a 4-point scale "Strongly disagree" to "Strongly agree" (Cronbach's alpha = 0.83).
	Science competence	Four-item composite: (1) ninth grader certain they can master skills in fall 2009 science course, (2) ninth grader confident can do excellent job on fall 2009 science tests, (3) ninth grader certain can understand fall 2009 science textbook, and (4) ninth grader confident can do excellent job on fall 2009 science assignments on a 4-point scale "Strongly disagree" to "Strongly agree" (Cronbach's alpha = 0.87).
	Science performance	6-point Likert scale: ninth grader's final grade in most advanced eighth grade science course ranging from "Class was not graded" to "A."

The first measure, science competence, is a composite of four items on 4-point Likert scale ranging from "strongly disagree" to "strongly agree." Science competence items include, "ninth grader certain can master skills in fall 2009 science course," "ninth grader confident can do excellent job on fall 2009 science tests," "ninth grader certain can understand fall 2009 science textbook" and "ninth grader confident can do excellent job on fall 2009 science assignments." Science competence indicates strong internal reliability estimates (Cronbach's $\alpha = .87$). Science recognition is the second composite measure using two items on 4-point Likert scale ranging from "strongly disagree" to "strongly agree." Items include, "ninth grader sees himself/herself as a science person" and "others see ninth grader as a science person." Science recognition reliability estimates indicate a strong score (Cronbach's α = .83). The third and final science identity measure is science performance. This is measured by a student's final grade in their most advanced eighth grade science course. This item was answered on a 6-point Likert scale ranging from "Class was not graded" to "A". Science competence, science recognition and science performance measures create the science identity latent construct, in which higher values represents a higher science identity.

Independent Variables

Bronfenbrenner's ecological theory suggests student development is influenced at the microsystem level: family, school and peer interactions (Bronfenbrenner, 2005; Renn, 2003). Independent variables selected in this study are based on extant literature that have been found to influence a student's science identity and science achievement outcomes. Microsystem variables are categorized by: (a) socioeconomic status (b) parent school-based influences, (c) peer network influences, (d) science classroom learning environment influences and (e) out-of-classroom science influences. Comparison groups include a student's gender, science enrollment and school location.

Student Background Latino student socioeconomic status is included in the model. Previous research has found socioeconomic status (measured by their parent's education and income) and a student's academic achievements are strongly correlated (Gandara & Contreras, 2009), in particular with science (Espinosa, 2011; Herrera & Hurtado, 2011). Therefore, this study uses a socioeconomic status variable created by HSLS:09 comprising of mother and father's education level, mother and father's occupation and family income (Ingels, Herget, Pratt, Dever, Copello & Leinwand, 2011). This socioeconomic status variable provides an index score of the family's relative social position based on parents' education, occupational prestige and family income.

Parental School-based Influence The parent engagement latent construct uses previous parental research as a guide to identify ecological factors impacting the student's achievement outcomes (DeWitt et al., 2013; Gilmartin et al., 2006; Gunderson et al., 2012; Mena, 2011; Venezia & Jaeger, 2013). This latent construct is measured using parental school engagement activities answered on a dichotomous scale 0 = no and 1 = yes. Engagement activities include parents "attended a school meeting," "attended parent-teacher conference," "served as a school volunteer," and "met with a school counselor" during the 2009-2010 school year.

Peer Network Influence A student's peer latent construct is measured with three variables answered on a dichotomous scale of "False" and "True". Peer interaction items were selected from literature demonstrating its influence on students' achievement (Gibson, Gandara & Koyama, 2004; Hanushek, Kain, Markman & Rivkin, 1999). A ninth grade students peer networks items include, "closest friend plans to go to college," "closest friend is interested in school," and "closest friend gets good grades."

Science Classroom Influence A student's science classroom learning environment were measured with five items answered on a 4-point Likert scale ranging from "strongly disagree" to "strongly agree." Science classroom interactions items were selected from previous literature showing to influence students' science achievement (Gilmartin et al., 2006, Duschl, Schweingruber & Shouse 2007; Hardré et al., 2007; NRC, 2012; Yaeger, 1996). Science teacher learning environment items include, "science teacher values/listens to students' ideas," "science teacher treats students with respect," "science teacher treats every student fairly," "science teacher thinks all students can be successful," and "science teacher thinks mistakes are OK if students learn."

Out-of-classroom Influence A student's out-of-classroom science experiences are guided from various studies that have found them to influence student achievement (e.g., Dierking, Falk, Rennie, Anderson, & Ellenbogen, 2003; NRC, 2009; NGSS, 2013; Wagstaff, 2014), in particular with science achievement outcomes (Cole, 2012; Darling, Caldwell & Smith, 2005; Gilmartin et al, 2006; Szechter & Carey, 2009). Science-related items were answered on a dichotomous scale, "no" or "yes" from a parent survey. Items include, "going to science or engineering museum," "participating in a school science fair," "participating in a science project," "working or playing on computer" and "visiting a library."

Comparison Variables

Previous research has found that STEM achievement differs by gender, with females exhibiting lower levels than males (Cheryan, Master & Meltzoff, 2015; Gilmartin et al., 2006). Therefore, understanding how science identity differs by different experiences is of interest in this study. A student's gender was taken from the base-year student survey, parent survey and/or school-provided sampling roster and these three sources provided a validity check. Gender is coded as 0 = male or 1 = female (see appendix for comparison variables and coding schemes). A student's science enrollment is also of interest as advanced science course enrollment leads to positive academic outcomes (Adelman, 2006). However, understanding how to raise science identity for students enrolled in regular science is also of importance, as studies have shown Latinos are more likely to enroll in regular science courses (Nord et al, 2011). Students who participated in regular science are coded as 0 and students enrolled in an advanced science class as 1.

Several studies have found differences in student outcomes by school characteristics (Harper, 2015; Strayhorn, 2009). Therefore, science identity differences and microsystems will be examined by school location. A Latino student school location will provide information on a student's environment and the surrounding population. The school location variable was originally coded as 1 = urban (large or mid-size city), 2 = suburban (urban fringe of large or mid-size city), 3 = town (large or small), and 4 = rural (outside or inside a Core-Based Statistical Area). This variable was recoded to combine town with rural locations. Please see appendix for complete comparison coding schemes and definitions.

Analytic Approach

Data Preparation

Within empirical studies, missing data among variables is not uncommon in national datasets (Ferron, Hess, Hogarty, Dedrick, Kromrey, Lang & Niles, 2004). Survey participants can omit items because they are given an option to skip items that they do not wish to answer, or a survey item does not apply to a respondent, or omitted by error, or for other reasons (Loehlin, 2004). HSLS attempts to screen the data from respondents in order to minimize missing data in the public dataset by including a student survey as counted if they met the following criteria: (1) At least 50 survey items were answered and at least 50 percent of the critical items were answered or (2) at least 30 items were answered and the mathematics assessment was completed (Ingles et al., 2013). To handle missing responses in the public dataset, a list-wise deletion approach will be used with the dependent and independent variables in order to provide unbiased estimates and an internally consistent covariance matrix (Loehlin, 2004; Pigott, 2011). In addition, frequency and descriptive distributions will be conducted in order to screen for normality and possible outliers to detect possible variable issues in the Latino subsample. Outliers and extreme case numbers falling outside of three standard deviations will be removed. Finally, a zero-ordered correlation matrix will be examined in order to understand the variable relationships and check for multicollinearity issues (Please see table 9). These data preparation approaches will help ensure that estimates and variances are unbiased, therefore strengthen the data analyses, interpretations and conclusions.

A structural equation modeling (SEM) approach is appropriate given the goals of this study, as this method establishes the validity of measurements theorized in the integrated bioecological theory of human development, science identity framework, and extant literature providing direct, indirect and total effect estimations (Kline, 2011; Mertler & Vannataa, 2002). SEM encompasses two components. The first is a measurement model, a variant of confirmatory factor analysis (CFA), assessing the degree to which measured variables reflect the intended latent constructs. The CFA model is a statistical claim about the associations among variables and is employed when there is: (a) substantive theory, empirical research or both to inform the creation of latent constructs and (b) prior information exists about the direction and magnitude of the parameter relationships (Brown 2006; Kline, 2011; Loehlin, 2004; Schreiber et al., 2006). For this study, the hypothesized CFA model will provide estimates to assess the effects of five latent constructs, including science identity (Kaplan, 2000; Kline, 2005). Once an adequate model is established, the second component is the structural model, focused on the direct and indirect paths. In SEM, direct effects refer to the effect of an independent variable on a dependent variable (Schreiber et al, 2006).

Previous studies have found parental, peer, classroom and out-of-classroom (e.g., independent variables) interactions have direct effects on a student's academic outcomes (e.g., dependent variable) (Loukas, Suzuki & Horton, 2006; Martinez et al., 2004; Muss, 1999; Plunkett & Bámaca-Goméz, 2003; Valadez, 2002; Woolley et al., 2009). For instance, Muss (1996) explains that face-to-face interaction with, and support from, family members and peers are among the most common and important proximal processes for students and academic outcomes. Indirect effects represent the effect of an independent variable in a dependent variable through a mediating variable (Schreiber et al., 2006). Literature suggests peer and student interactions have been found to be directly predictive of school connectedness and indirectly linked to school behavior among middle school students (Loukas et al., 2006). Furthermore, Woolley and colleagues (2009) found parental support and monitoring were directly and indirectly linked to various Latino student academic outcomes (e.g., school behavior, school satisfaction, time spent on homework and grades). Therefore, it is hypothesized parental and peer influences have direct and indirect effects on science identity. That is, peer and parental influences will have direct and indirect effects through science classroom and out-of-classroom science influences on science identity. Finally, total effect in SEM includes latent constructs (i.e., parental, peer, science classroom, and out-of-classroom science) summation of direct and indirect effects on science identity. Given the above, this study seeks to understand the predictive nature of the explanatory latent constructs on science identity using mathematical equations based on linear regressions to identify the strength of relationships among latent, measured and unexplained variables (Bryne, 2006; Kline, 2011). In addition, SEM allows group comparisons through measurement invariance to examine differences in the SEM model.

Analytic Method

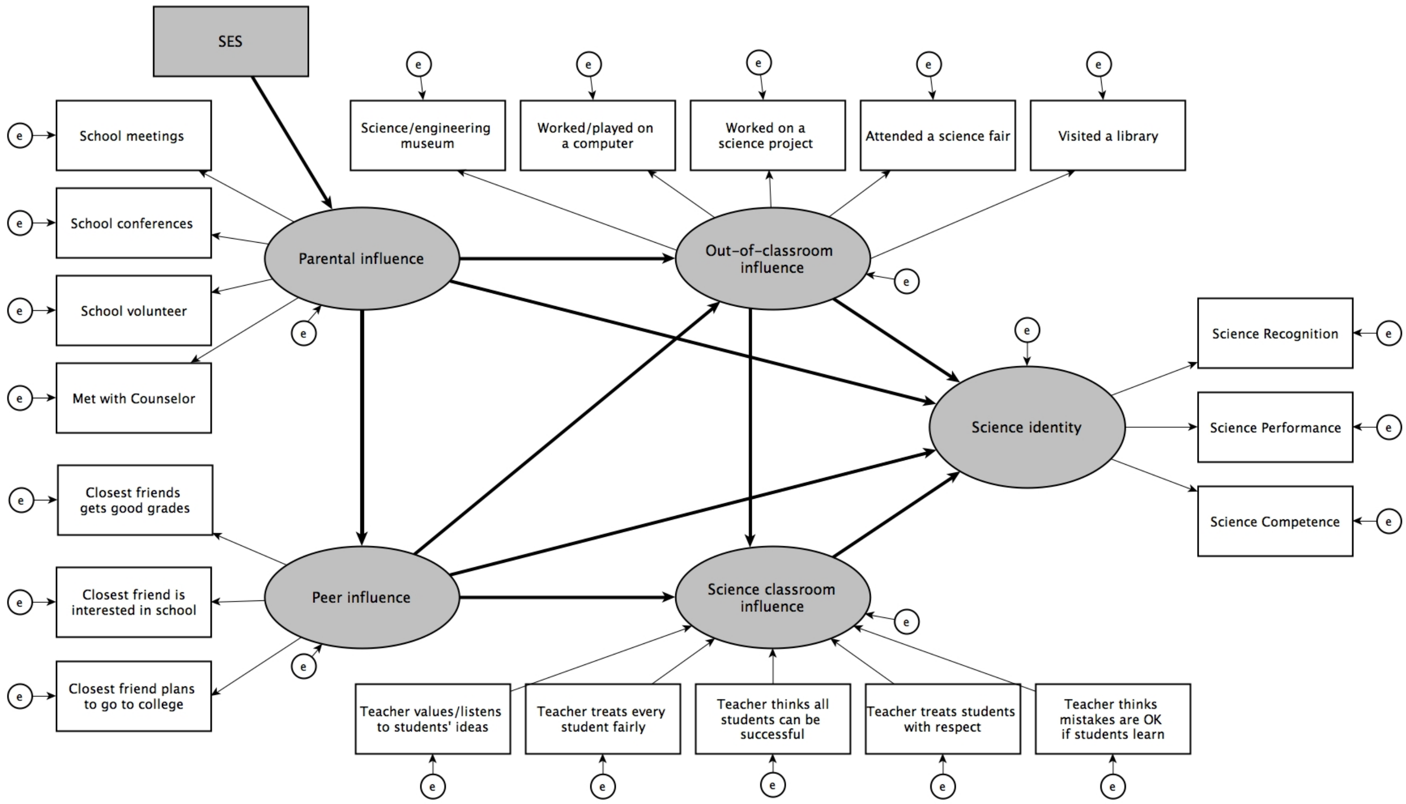
Preliminary Analysis

The sample included 3,516 ninth grade Latinos in the HSLS:09 dataset. Latino students were removed from the analysis if they were missing parent survey item responses. This approach reduced the sample size to 2,432 respondents. Second, to ensure stability of the parameter estimates, student and parent were excluded if the respondents missed an item, an item was a non-response or an item was a legitimate skip. In addition, frequency and descriptive distributions were used to screen for normality and possible outliers to help ensure estimates and variance were unbiased. Using SPSS (Version 19), nine outliers were removed because they fell outside of three standard deviations. Furthermore, a list-wise deletion approach was used to handle missing values in the dependent and independent variables to provide unbiased estimates and internally consistent covariance matrix (Loehlin, 2004; Pigott, 2011). The final analytic sample with complete student and parent data included 1,658 respondents. The final sample satisfied the recommended parameter guidelines, thus providing stability in the results (Kline, 2011). All preliminary analyses were done using SPSS, such descriptive statistics (e.g., means, standard deviations, and correlations) and the initial reliability of composite measures proposed. The measurement model and SEM component of the analysis used a maximum likelihood estimation approach in STATA (13th edition) as the data were distributed normally with a few variables having a slight distribution skew within reasonable ranges (Kline, 2011).

Measurement Model Estimation

The measurement model employed maximum likelihood estimation procedures measuring how well the variables reflect the intended latent constructs. That is, parent, science classroom, peer, out-of-classroom, and science identity measured variables will create five statistically rigorous theoretical microsystem latent factors. In this manner, the CFA model focuses on the relationship between latent factors represented by large grey circles and their measured variables represented with a white rectangle graphic (Schreiber, 2008). The small circles represent the measurement errors in the measured variable that are not explained by the latent construct. The single head and dual head arrows are called paths, whereas the direction represents the directional effects from one variable to another (latent or measured).

Figure 3. Hypothesized SEM Science Identity Measurement Model



Notes: Large circles = latent construct. Rectangles = measurement variable. Arrows = paths. Boldface arrows indicate hypothesized structural component. e = error.

Measurement Model Fit Evaluation

To test the validity of the hypothesized measurement model, STATA software is used to determine the adequacy of its goodness-of-fit index criteria to the sample data, interpret the parameter estimates, and consider equivalent or near-equivalent models (Bryne, 2006; Kline, 2011). The path from each of the proposed latent variable constrains one of the measured variables to one in order to set the scale of the latent variables. The chi-square test (Cochran, 1952) is the most commonly used test to check model fit, however, recent literature suggests limitations to this test, where chi-square tests tend to reject reasonable models if there is a large sample (Van de Schoot, Lugtig & Hox, 2012).

Therefore, this study uses three approximate fit indices that are widely reported in the SEM literature (Kline, 2011). The root mean square error of approximation (RMSEA) is a badness-of-fit index where the value of zero indicates the best fit (Steiger, 1990), in which a RMSEA ≤ .05 is a recommended acceptable threshold (Kline, 2011). Hu and Bentler (1999) also suggest using a comparative fit index (CFI) and standardized root mean square residual (SRMR) together. The CFI is an incremental fit index that measures the relative improvement in the fit of the researchers model of that of a baseline (Kline, 2011), whereas the SRMR identifies differences between observed and predicated covariance residuals. They recommend a combination threshold at CFI ≥ .95 and SRMR ≤ .08 for an acceptable fit (Hu & Bentler, 1999). Together, these fit indices provide information of the overall model fit.

Science Identity Structural Equation Modeling

Once an adequate measurement model is established, the next phase of this study consists of the structural model (SEM) component. The hypothesized CFA model provides estimates to assess the effects of the four latent constructs on Latino students' science identity (Kaplan, 2000; Kline, 2005). Paths between latent variables that are not statistically significant will be removed from the hypothesized STEM model to provide a parsimonious model.

SEM Group Comparisons

The final phase includes an SEM multiple group comparison where two or more samples of respondents are compared using similar models (Kline, 2011; Meredith, 1993; Sass, 2011). The comparison groups are guided from extant literature highlighting distinctive experiences (Cheryan, Master & Meltzoff, 2015; Gilmartin et al., 2006).

Therefore, the multiple group comparison for this study includes three comparison groups. Student focused comparison groups includes: (1) Latino males and females, and (2) Latino students enrolled in general science and advanced science classes. One school focused comparison group is examined: urban, suburban and town/rural located schools. Employing a multiple group analysis allows this study to adequately assess the potential differences in both the effects of the four latent factors on a student's science identity and the factor means of the proposed latent constructs (Sass, 2011).

Measurement invariance will be tested across groups in order to compare the covariance structure to confirm they are equal across groups (Dimitrov, 2006). First, this study will estimate an unconstrained configural model to establish a baseline model for comparisons (Sass, 2011; Wicherts & Dolan, 2010). Once this is established, the configural model will be used as a basis for comparison to test for invariance. Second, a metric invariance model will be estimated with the factor loadings fixed equal with both groups. In comparing models, Dimitrov (2006) suggests using the RMSEA index and not the chi-square difference to measure model fit. If the metric invariances are not different from the baseline model, the measurement variables are found to be equivalent and examining the paths across the latent variables is appropriate (Dimitrov, 2006). SEM group comparisons will be conducted by repeating each of these steps to understand the indirect, direct, and total effects.

Chapter 5. Results

Introduction

This chapter provides HSLS:09 data preparation, descriptive results and examination of the research questions. Research question number one is examined to understand the hypothesized science identity model fit with HSLS:09 data. This is accomplished by using a confirmatory factor analysis approach and a structural equation model building process. Research question number two examines the structural equation model paths to understand the total, direct and indirect effects of parental, peer, science classroom and out-of-classroom influence on the development of science identity. Finally, research question number three is examined by testing measurement invariance of the three proposed comparison groups on the integrated science identity model. This chapter also describes the limitations of the study.

Descriptive Results

The descriptive statistics findings reveal ninth grade Latino students selected in this analytic sample entered high school with relatively high science grades. That is, 66 percent of students received a final grade of "B or above" in their most advanced science course in 8th grade (M = 3.78, SD = 1.06). Science performance appeared to play a positive role in their science confidence during Fall 2009. Fifty-one percent of Latino ninth graders were certain they could understand their science textbook (M = 1.55, SD = 0.78), 67 percent were confident they could do an excellent job on their science test (M = 1.76, SD = 0.74), 71 percent were certain they could master skills in their science class (M = 1.79, SD = 0.72) and 78 percent were confident they could do an excellent job on their science assignments (M = 1.90, SD = 0.70). In addition, 36 percent of Latino ninth graders viewed themselves as science individuals (*M* = 1.19, *SD* = 0.88) and 30 percent of these students believed that others view them as science individuals (*M* = 1.11, *SD* = 0.82). These findings suggest Latino students' in this study are entering high school with a fairly high science identity (e.g., science class grades, science competence, and science recognition). However, additional insights are discovered when the entire HSLS:09 ninth grade students and their science identity measures are examined.

In general, Latino ninth grade students had lower scores on science identity measurement items compared to the entire HSLS:09 ninth grade students. Descriptive findings reveal that the entire ninth grade sample agreed they saw themselves as a science person at 43.2 percent (*M* = 1.34, *SD* = 0.90), others saw them as a science person at 38.7 percent (*M* = 1.27, *SD* 0.85), they were certain they can understand current science textbook at 58.8 percent (*M* = 1.87, *SD* = 0.74), they were certain they can master skills in current science class at 73.7 percent (*M* = 1.88, *SD* = 0.72), they were confident they can do an excellent job on their science assignments at 81.1 percent (*M* = 2.00, *SD* = 0.70), they could do an excellent job on their science tests at 72.7 percent (*M* = 1.87, *SD* = 0.74), and 76.4 percent indicated they received a "B or higher" in their most advanced science class (*M* = 4.07, *SD* = 1.02). These science identity findings uncover that Latino students are scoring below the ninth grade average. In particular with Asian and Caucasian students whom have higher science identity scores, on average, compared to Latino students. For instance, 52 percent of Asian students (*M* = 1.37, *SD* = 0.90) and 44 percent of Caucasian students (*M* = 1.54, *SD* = 0.86) see themselves as a science person compared to 36 percent of Latino students (*M* = 1.19, *SD* = 0.88).

Differences were also found between Latino gender, science enrollment, and school location. Latinas indicated a higher science competence and science performance compared to Latino males, but lower science recognition. Latino students enrolled in a ninth grade advanced science class had higher science recognition, competence and performance statistical means compared to Latinos enrolled in a regular science class. Urban ninth grade Latino students had higher levels of science recognition, competence and performance means compared to Latinos in suburban and town/rural locations.

Table 2. Descriptive Statistics for Full Latino Sample

Latent Variable	**Measured Variable**	**Min.**	**Max.**	**Mean**	**SD**
Science identity					
	Science recognition	0	3	1.15	0.78
	Science competence	0	3	1.75	0.62
	Science performance	0	5	3.78	1.06
Background influence					
	Socioeconomic status	-2	3	-0.39	0.73
Parental science influence					
	Attends school meetings	0	1	0.76	0.43
	Attends school conferences	0	1	0.55	0.50
	Volunteers at school	0	1	0.24	0.43
	Met with a school counselor	0	1	0.43	0.50
Peer science influence					
	Friend gets good grades	0	1	0.85	0.36
	Friend is interested in school	0	1	0.68	0.47
	Friend plans to go to college	0	1	0.88	0.33
Science classroom influence					
	Teacher values/listens to students' ideas	0	3	2.13	0.70
	Teacher treats students with respect	0	3	2.25	0.67
	Teacher treats every student fairly	0	3	2.16	0.73
	Teacher thinks all students can be successful	0	3	2.27	0.67
	Teacher thinks mistakes are OK if students learn	0	3	2.12	0.69
Out-of-classroom science influence					

	Science/engineering museum	0	1	0.50	0.50
	Worked or played on a computer	0	1	0.79	0.41
	Worked on a science project	0	1	0.20	0.40
	Attended a science fair	0	1	0.46	0.50
	Visited a library	0	1	0.64	0.48
Comparison Group					
Student level	*Student's gender: Female (Male reference group)*	0	1	0.52	0.50
	Advanced science class	0	1	0.52	0.50
School level					
	Location: Urban	0	1	0.31	0.46
	Location: Suburban	0	1	0.36	0.48
	Location: Town/Rural	0	1	0.32	0.47

With regard to parental engagement, more than three-fourths of the parents of Latino students attended school meetings, more than half attended parent-teacher conferences, less than half of the parents met with a school counselor and less than one-fourth volunteered at school. Differences in parental engagement can be found within school locations and science enrollment. Urban parents were more likely to engage in school settings than parents in suburban and rural/town settings. Also, Latino students enrolled in advanced science classes were more likely to have parents engaged in school settings compared to students enrolled in regular science classes.

Overall, the majority of ninth grade Latinos in the HSLS:09 dataset had a close friend that was interested in school, received good grades in school, and planned to go to college. Latina students, Latinos enrolled in an advanced science class as well as urban and suburban Latinos were more likely to have slightly higher peer influence compared to Latino males, Latinos in regular science and those in town/rural settings.

The majority of Latino students had a positive view of their science classroom-learning environment. That is, 83 percent agreed that their science teacher valued and listened to students' ideas, 89 percent agreed that teachers treated students with respect, 83 percent agreed that teachers treated every student fairly, 84 percent agreed teachers believed mistakes in the classroom were OK if students learned, and 89 percent agreed that teachers believed all students can be successful. Differences of classroom perceptions appeared to be in whether Latinos were enrolled in regular or advanced science classes. Latinos were more likely to have a positive classroom perception if they were enrolled in advanced science classes.

Out-of-classroom science influence varied in participation rates. Latinos playing or working on a computer with a parent at 79 percent was the highest out-of-classroom science participation, followed by visiting a library, going to a science/engineering museum, working on a science project and attending a science fair. In general, Latinos in urban and suburban school settings appeared to be engaged in these activities at higher rates compared to Latino males and town/rural school settings. Also, there were minimal differences found in these activities within science enrollment (Please see appendix C through F for complete descriptive results).

Examination of Hypothesis 1

Confirmatory Factor Analysis

A confirmatory factor analysis (CFA) was conducted to understand how the HSLS:09 data fit to the hypothesized science identity model. Specifically, how the hypothesized measured variables load on the five latent factors, "Science identity", "Science classroom microsystem", "Out-of-classroom science microsystem", "Peer influence microsystem" and "Parental engagement microsystem." This analysis included a subsample of Latino students (n = 1,658) in which students were linked to their parents' survey. The CFA model for the five latent factors reveal an adequate model fit by estimation standards; RMSEA= .034, CFI = .958, TLI = .950 and SRMR = .033 (Yu & Muthan, 2002; Kline, 2005; Kaplan, 2008).

Table 3. Full Measurement Model Results

Latent Construct	**Measured Variables**	**Coefficient**
Science Identity		
	Science recognition (S)	0.62***
	Science competence (S)	0.77***
	Science performance (S)	0.46***
Parental influence		
	Attends school meetings (P)	0.52***
	Attends school conference (P)	0.46***
	Volunteers at school (P)	0.48***
	Met with a school counselor (P)	0.33***
Peer influence		
	Closest friend gets good grades (S)	0.49***
	Closest friend is interested in school (S)	0.49***
	Closest friend plans to go to college (S)	0.61***
Science classroom influence		
	Science teacher values/listens to students' ideas (S)	0.82***
	Science teacher treats every student fairly (S)	0.86***
	Science teacher thinks all student can be successful (S)	0.84***
	Science teacher treats students with respect (S)	0.79***
	Science teacher thinks mistakes are OK if students learn (S)	0.67***
Out-of-classroom science influence		
	Science or engineering museum (P)	0.48***
	Worked/played on a computer (P)	0.32***
	Worked on a science project (P)	0.34***
	Attended a science fair (P)	0.40***
	Visited a library (P)	0.42***

* $p \le .05$ ** $p \le .01$ *** $p \le .001$. Student survey = (S). Parent Survey = (P).

Structural Equation Model Building

The hypothesized CFA model findings indicate a good fit to the observed data. However, Kline (2011) recommends engaging in a model-building process in order to provide a parsimonious model and to minimize alternative structural explanations. First, hypothesized structural paths were removed and the change in model fit estimates was examined (e.g., X^2, CFI, RMSEA and SRMR) providing information on whether to keep or remove structural paths. For instance, parental engagement influence on science classroom learning environment, out-of-classroom influence on science classroom learning environment, and peer influence on out-of-classroom structural paths were removed because they were not statistically significant paths. In fact, the model fit estimates improved with the removal of each of these structural paths (Kline, 2011). Removing the direct hypothesized paths of parent school-based influence on science classroom perceptions (Model 1), peer influence on out-of-classroom influence (Model 2) and out-of-classroom influences on science classroom influences (Final model) improved the overall model fit (See table 4.)

Second, modification indices were examined in the analysis and found significant covariance relationships with: a) parent teacher-conferences and parent meeting with a counselor (Z = 5.83), b) student having friends interested in school and friends who get good grades (Z = 3.65), c) science teachers treating students with respect and science teachers treating students fairly (Z = 5.84), d) parents/students working on a science project and attending a science fair (Z = 7.62), and e) visiting a science museum and library (Z = 2.45). The covariance relationships are shown with double-headed arrows represented and measurement error circles (See figure 4). By engaging in the SEM model building techniques, the final model revealed a parsimonious model compared to the hypothesized model, which produced slightly improved model fit statistics; RMSEA=

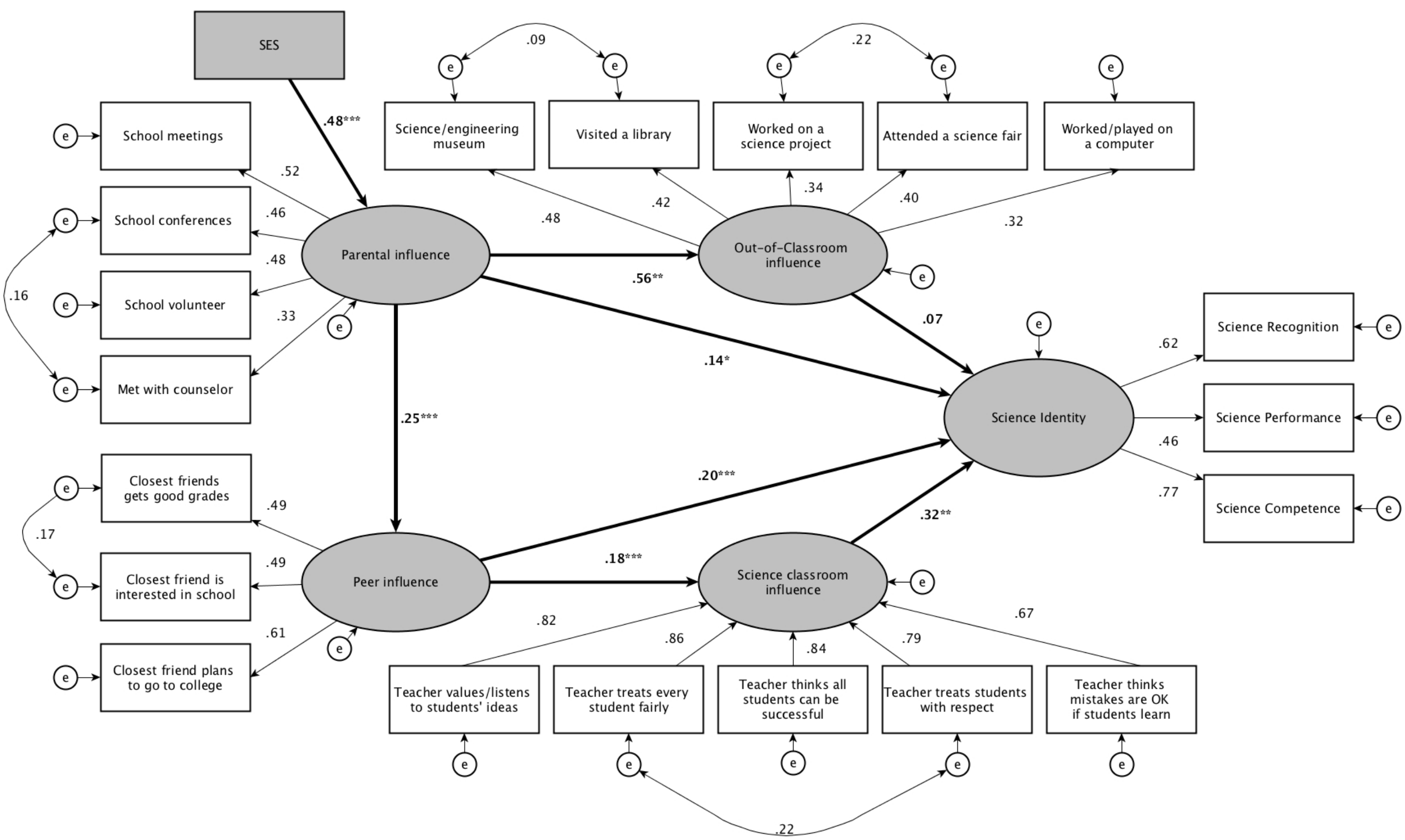
.034, CFI = .959, TLI = .951, and SRMR = .033 (Yu & Muthan, 2002; Kline, 2005; Kaplan, 2008). The final model indicates a good model fit to the observed data.

Table 4. Measurement Model Fit Statistics

Structural Models	X^2 (df)	ΔX^2 (df)	RMSEA	CFI	SRMR
Hypothesized model	506.814 (174)		0.034	0.958	0.033
Model 1 (removed parent --> classroom)	506.947 (175)	0.133(1)	0.034	0.959	0.033
Model 2 (removed peer --> out-of-classroom)	508.023 (176)	1.209(2)	0.034	0.959	0.033
Final Model (removed out-of-classroom --> classroom)	508.180 (177)	1.366(3)	0.034	0.959	0.033

ΔX^2(df) results are differences to the hypothesized model.

Figure 4. Final SEM Model with Configural Standardized Estimates (n = 1658)



Notes: X^2(df) = 508.180(177), RMSEA = .034, CFI = .959, SRMR = .033

Examination of Hypothesis 2

Direct Effects

When examining the results of the relationships between a student's socioeconomic status background, parental engagement, peer, science classroom and out-of-classroom influences, this study found statistically significant positive direct effects on Latinos' science identity. This study hypothesized there would be direct effects with the proposed latent constructs on the development of science identity with peer influence having the largest effect. The ninth grade Latino sample found that the science classroom-learning environment was the most powerful standardized direct effect on Latinos science identity. This relationship was positive and statistically significant ($\beta = 0.32$, $p < 0.001$). That is, as Latinos' ninth grade perception of science teachers increases (e.g., valuing students' ideas, respecting students, treating all students fairly, thinking all students can be successful and creating an environment of students making mistakes is OK if students learn), so does their science identity. This finding has a medium effect size. Furthermore, peer influences ($\beta = 0.20$, $p < 0.001$) were found to have a positive and statistically significant direct effect on science identity. Latinos' peer influence, in which students have friends who have an interest in school, receive good grades and plan to go to college, was found to increase their science identity with a small to medium effect size. Finally, a parent's level of school-based engagement followed as the third most powerful direct predictor on developing their child's science identity ($\beta = 0.14$, $p < 0.05$), obtaining a small effect size.

Indirect Effects

For Latino students, parental engagement had statistically positive indirect effects on peer influence ($\beta = 0.25$, $p < 0.001$) and out-of-classroom influence ($\beta = 0.56$, $p < 0.001$). Of these two latent constructs, peer influence appeared to be a crucial mediating construct on building a students' science identity. For instance, higher levels of parental engagement had a positive relationship with peer influence, which then had a direct positive effect on science identity. In addition, peer influence also manifested through a student's classroom perceptions. In other words, increased parental school-based engagement led to increased peer influence, which contributed to having a positive science classroom learning environment and ultimately led to increased science identity formation. Although parental engagement and peer influence played an important role by indirectly effecting science identity in this model, parental engagement and out-of-classroom influence had the most powerful standardized path in the model. However, Latinos' involvement in out-of-classroom learning activities did not have a statistically significant relationship with the development of science identity.

Examination of Hypothesis 3

When examining the Latinos' science identity model parameters, this study found measurement invariance in nested models between gender, science enrollment and school location. The measurement variables are found to be equivalent for the comparison groups and examining the paths across latent variables is appropriate. The first comparison group found adequate evidence of measurement invariance between males and females. The configural unconstrained model was fully estimated and model fit estimates revealed acceptable results: X2 (354) = 696, CFI = 0.957, RMSEA = 0.034, SRMR = 0.037. The metric invariance was examined by constraining the factor loadings to be the same for both groups and the results were not statistically different from the configural model.

The second comparison group also found adequate evidence of measurement invariance between regular science and advanced science enrollment. The unconstrained model was fully estimated and model fit estimates reveal acceptable results: X2 (354) = 677, CFI = 0.960, RMSEA = 0.033, SRMR = 0.037. The final comparison group found an adequate evidence of measurement invariance of urban, suburban and town/rural models. The unconstrained model was fully estimated and model fit estimates reveal acceptable results: X2 (531) = 970, CFI = 0.946, RMSEA = 0.039, SRMR = 0.037 when constraining the factor loadings to be the same for both groups. The metric invariance results were not statistically different from the configural model (Please see appendix for tests of invariance between the comparison groups).

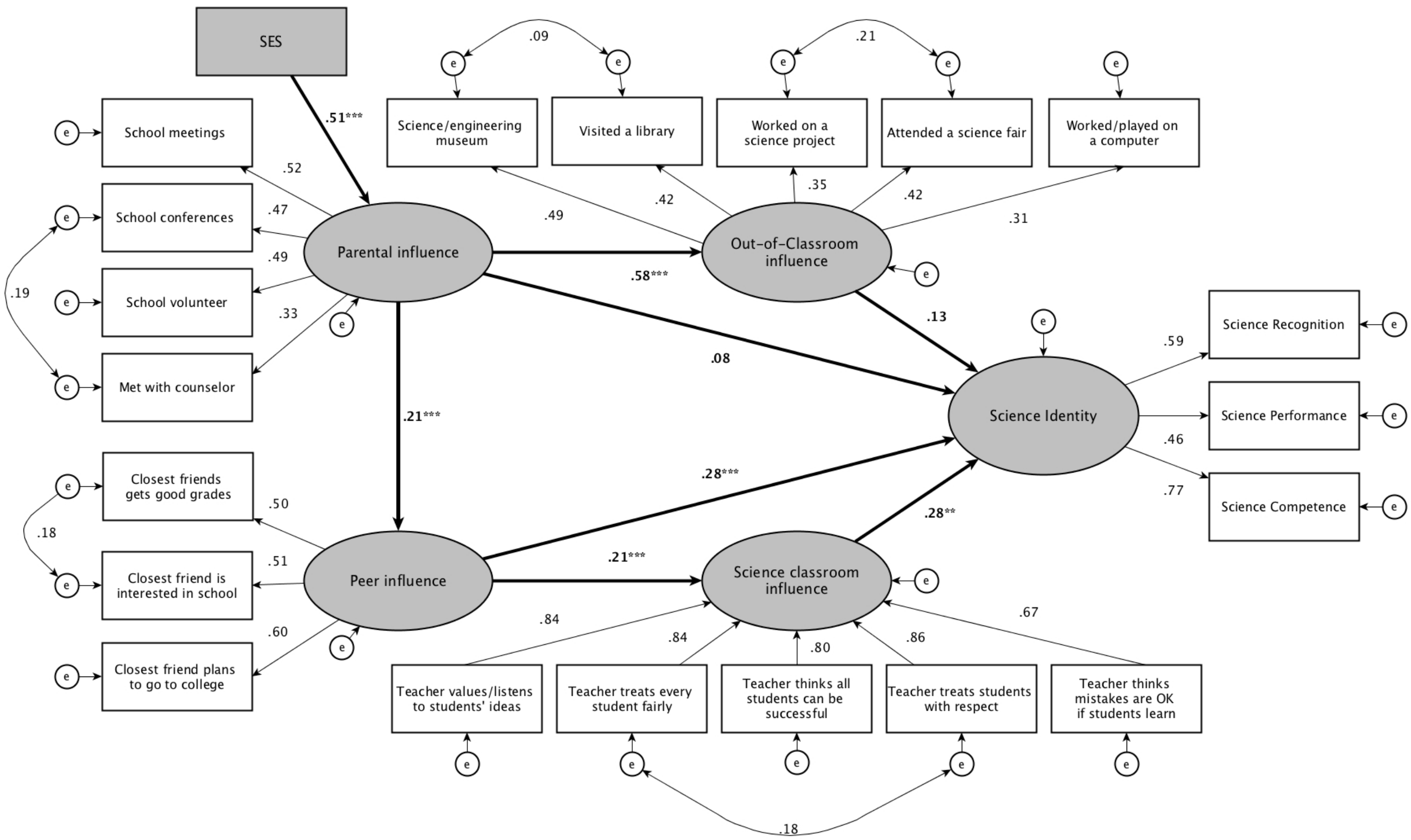
Examination of Hypothesis 3a

Latino Students

For the Latino male sample, findings reveal that a positive science classroom-learning environment and students' peer influence were the most powerful direct predictors of science identity development. As Latino ninth grade males' perception of their science classroom-learning environment increases, so does their science identity ($\beta = 0.28$, $p < 0.001$). Also, as Latino males' positive peer network increases (i.e., friends interested in school, received good grades, and planned to go to college), so does their science identity ($\beta = 0.28$, $p < 0.001$). Surprisingly, a parent's level of school-based engagement was not a statistically significant direct effect on males' science identity.

However, parent school-based engagement had statistically significant direct effects with peer influences (β = 0.23, $p < 0.001$), and subsequently peer influences had positive associations with classroom influences and science identity.

Figure 5. Latino Male SEM Model with Configural Standardized Estimates (*n* = 800)

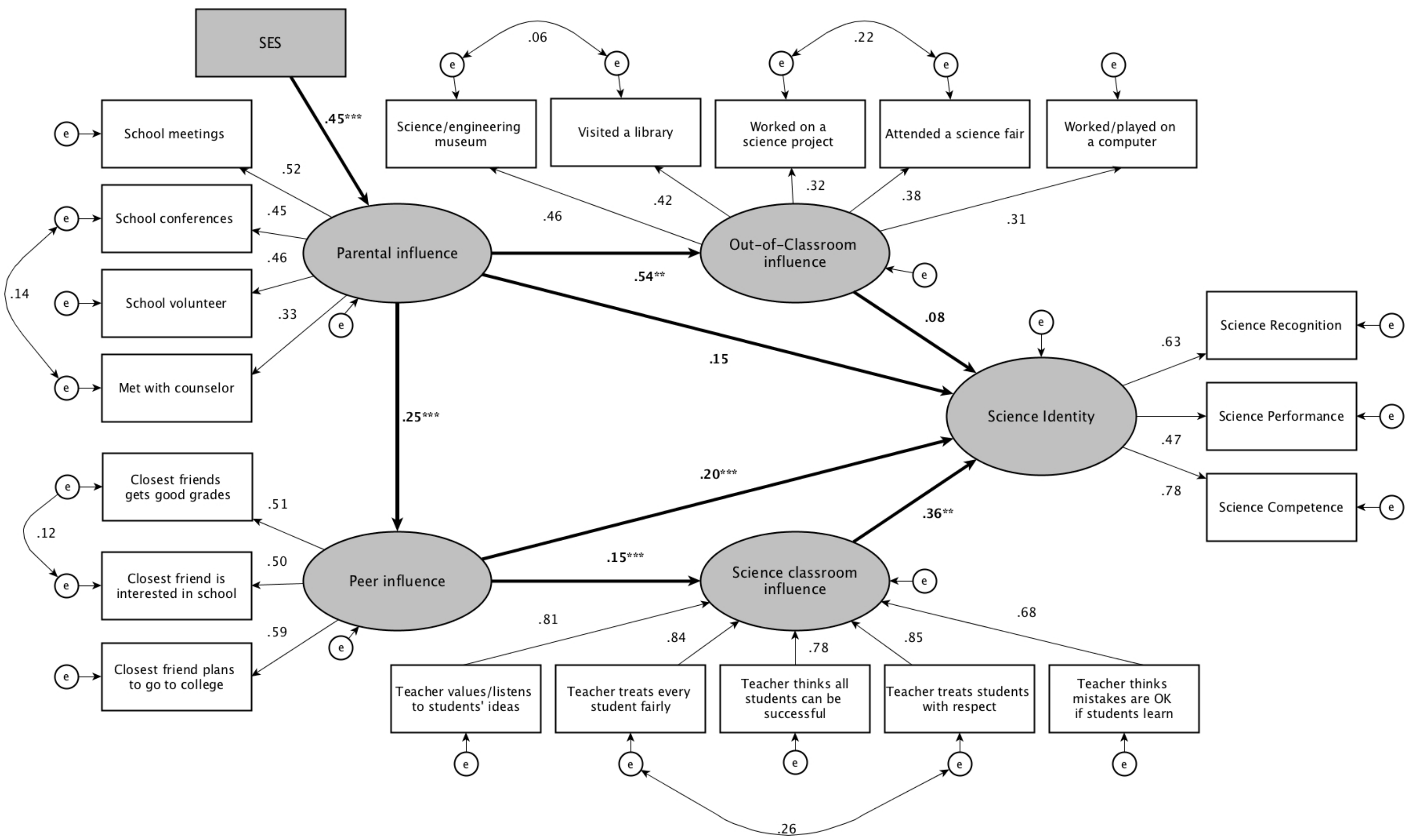


Notes: X^2(df) = 375.704(177), RMSEA = .034, CFI = .957, SRMR = .040

Latina Students

Perceptions of a science teachers' classroom-learning environment was the most powerful direct predictor of science identity development for Latinas (β = 0.36, $p < 0.001$). This finding has a statistically larger direct effect on science identity for Latinas than their Latino male counterparts (Wald = 4.792, $p < .05$). Similar to Latino males, peer influence (β = 0.19, p < 0.001) and a parent's level of school-based engagement (β = 0.16, p < 0.001) were statistically significant direct effects for Latinas, although there are notable differences in magnitude, these associations were not statistically different compared to their male counterparts.

Figure 6. Latina Female SEM Model with Configural Standardized (*n* = 858)



Notes: X^2(df) = 321.271(177), RMSEA = .034, CFI = .957, AIC = 48648.663, SRMR = .039

Examination of Hypothesis 3b and 3c

Science Enrollment and School Location

The science identity model did not statistically vary based on Latino ninth grade science class enrollment (i.e., advanced versus regular science class) and school location (i.e., urban, suburban and town/rural locations). Although there are differences in standardized direct structural paths, the Wald Test revealed no statistical differences.

Limitations

There are several dissertation limitations that should be considered when interpreting the results. This analysis was limited to the variables in the HSLS:09 dataset, which limited the ability to include desired variables. First, this analysis does not account for Latino subgroups. Research has shown how racial subgroups can have different educational experiences due to distinct historical contexts, social conditions and identities (Museus et al., 2011). The HSLS public dataset does not disaggregate by Latino subgroups (e.g., Puerto Ricans, Cubans, Mexicans, etc.), thus differences in science identity and ecological latent factors among these subgroups are limited to Latino students in the aggregate. For example, HSLS:09 does not include survey items on ethnic identities (i.e., Latino ethnic identity) that may impact their science identity, as studies have determined the impact on science performance (Aschbacher & Roth, 2010; Walton & Cohen, 2007). Self-selecting as a Latino on this survey does not fully unpack how and which ways they identify with being Latino. This limited the ability to capture the magnitude of identifying as Latino and its influence on science identity, that is, students that identify more or less with being Latino and its impact on their science identity development.

Second, there is a limited set of survey items in HSLS:09 examining non-traditional parental engagement influence (e.g., parents that are active in members in school decision-making, parents' funds of knowledge, etc.), out-of-classroom experiences, and culturally relevant teaching and curriculum. Research has found that

Latino parents may engage with their children in various ways not visible to the school system (Arellano & Padilla 1996; Simpkins, Price & Garcia, 2015). In addition, out-of-classroom experiences need to be examined further in order to understand informal settings that have not been included in national surveys. For instance, Dierking and colleagues (2003) claim there is a need to explore other real-world situations, such as summer camps, parent's workplace, the Internet, and other out-of-classroom learning opportunities, in order to understand the impact of informal activities that current students are experiencing. In regard to classroom factors, science curriculum and/or a teacher's ability to provide culturally relevant teaching practices may enhance educational ability of Latino students (Ladson-Billings, 2006; Rolon, 2003; Museus et al., 2011).

Third, this dissertation does not examine specific subgroup comparisons due to the research design and the small size in the data. This study did not include Latino students with missing parent responses due to the goals of this study. In general, Latino students with missing parent responses on average had slightly lower means on the selected variables compared to Latino students with parent responses. For example, slight differences were found when examining Latinos without parent responses and how they saw themselves as a science person ($M = 1.10$, $SD = 0.85$) compared to students with parent responses ($M = 1.19$, $SD = 0.88$).

Finally, the small sample size did not allow comparisons between Latino males enrolled in a regular science class located in an urban school compared to Latino males enrolled in an advanced science class located in an urban school. In addition, this study does not examine school locations by geographic regions. That is, experiences for Latinos in urban schools located in the western region of the United States may be different than for those Latinos located in urban schools located in the eastern region. Finally, this study is limited to SEM nested models. To provide a more generalizable Latino sample, future research should attempt to include a more inclusive and robust sample that includes various subgroups and employs a two-level SEM in order to strengthen this research, thus improving the data analyses, interpretations and conclusions.

Chapter 6. Discussion, Implications & Conclusions

Discussion

The results from this dissertation contribute to the expanding research literature on Latino students and STEM. Various ecological influences were explored on the development of Latino science identity through an anti-deficient achievement lens, guided by Bronfenbrenner's Ecological Model and Carlone and Johnson's Science Identity Framework. Science identity has been shown to improve science-learning trajectories, especially for underrepresented populations in STEM (Brown, Henderson, Gray, Donovan, Sullivan, Patterson & Waggstaff, 2015; Carlone & Johnson, 2007; Kane, 2015). Few studies have focused on the development of science identity in secondary settings using a SEM approach for underrepresented STEM populations. Therefore, the goals of this dissertation were to develop a Latino high school science identity latent construct by using a confirmatory factor analysis approach, uncover direct and indirect ecological (e.g., parental, peer, classroom and out-of-classroom) influences on the development of science identity, understand how these ecological domains interact with one another and examine the science identity development model for different Latino comparison groups. Results reveal five major conclusions that can be drawn from the results of this dissertation.

First, this study examines one racial/ethnic population using a national dataset in order to disaggregate data on a few Latino characteristics for a more authentic understanding of the Latino population. Previous studies have demonstrated the importance of disaggregating data by racial and ethnic subgroups (Gloria & Rodriguez, 2000; Museus & Vue, 2013). This study adds to existing literature by highlighting the importance of other factors, such as gender, science class enrollment and school locations. Second, findings in this study confirm Carlone and Johnson's Science Identity Framework using a confirmatory factor analysis approach. This study is the first to report CFA results on science identity measures located in the HSLS:09 dataset. The science identity construct revealed science competence had a higher standardized coefficient, followed by science recognition and science performance for Latino ninth grade students. Third, findings in this study suggests various ecological (e.g., parental, peer, classroom and out-of-classroom) influences play indirect and direct roles in developing Latinos' science identity. Peer, parental school-based involvement and science classroom environmental factors revealed stronger total effects than other ecological factors in the model. Out-of-classroom influences had a weaker and statistically insignificant influence on Latino science identity.

Fourth, findings confirm differences in the science identity model exist between genders. Researchers have previously found gender differences in science-related outcomes (Catsambis, 1995; Else-Quest et al., 2013; Gilmartin et al., 2006; Pomerantz, Altermatt & Saxon, 2002). This study adds to the existing literature by highlighting gender science identity differences in high school settings. Furthermore, Latinas and Latinos experience ecological influences similarly, yet they have different effects on their science identity development, highlighting the importance of examining Latino subgroup factors and ecological environments. Finally, the SEM analytic approach in this dissertation provided the ability to take indirect influences into the model thus improving the understanding of these relationships to the overall model. Studies using regression techniques (e.g., linear regression, logistic regression, etc.) provide results that may be misleading, as these approaches do not take into account indirect influence. Together, these five major conclusions add to the existing body of literature. The following sections provide a discussion arranged by research hypothesis.

Hypothesis 1

The first research question examined whether the proposed model fit the HSLS:09 dataset. This dissertation used the integrated Bronfenbrenner's (1979) Ecological Model and Carlone and Johnson (2007) Science Identity Framework to establish valid theorized latent constructs using CFA and SEM approaches, and the hypothesis was supported. The model fit indices from the final CFA model, which revealed that Latino science identity in this study was developed across various ecological influences, either directly or indirectly. This dissertation strengthens the integrated theory of Bronfenbrenner and Carlone and Johnson by presenting CFA results located in the HSLS:09 dataset.
The science identity construct revealed science competence had a larger standardized coefficient, followed by science recognition and science performance for Latino ninth grade students. This finding stresses Latino science competence may be a stronger factor in developing science identity in high school, whereas science recognition was found to be the most salient factor in developing and solidifying a science identity for women of color in postsecondary settings (Carlone & Johnson, 2007). Combined, these findings begin to challenge the notions of science performance (e.g., science standardized exams) as a sole measure for science progression in the pipeline.

Consistent with Bronfenbrenner (1979), the proposed microsystems in this study established valid latent constructs. Bronfenbrenner (1979) claims that at the microsystem level, parents, teachers and peers influence students' development. The SEM component of this study found parental, peer and classroom environmental microsystems had direct, indirect and total effects on the development of Latinos ninth grade science identity. That is, higher levels of science identity were predicted when parents of Latino students were engaged in their child's school-based microsystem, Latino students were engaged in a positive peer microsystem and Latino students perceived a supportive science classroom microsystem. Latino students exposed to less of these microsystems were predicted to have lower levels of science identity. Latino parents, who are more likely to have relatively low levels of formal education, may consequently lack the formal knowledge of how the U.S. education system works and may not able to assist with schoolwork or pass along any school insights onto their children (Gandara & Contreras, 2009). Equally, Latino parents with limited English proficiency or who have cultural misunderstandings when interacting with the school often feel unwelcomed and misunderstood by the educational system (Delgado-Gaitan, 1991; Hill & Torres, 2010; Perez & McDonough, 2008). The reciprocal interaction of parent, peer and science teacher microsystems found in this study are necessary in order to develop Latino students' science identity (Bronfenbrenner, 1979).

Previous research has found that the combination of parental and peer support creates academically resilient Latino students (Gonzalez & Padilla, 1997). This study examined these microsystems and together created a powerful mesosystem that impacted science identity development (Bronfenbrenner, 1979). That is, the higher levels of parental school-based engagement directly influenced students' positive peer networks, which then influenced science identity in greater magnitude compared with parental influence alone. The peer and science classroom mesosystem was also found to influence science identity. These mesosystems created a synergistic influence upon Latino science identity. Hypothesis number two further explores these relationships and their direct and indirect impact on Latinos science identity.

Hypothesis 2

Student environments are complex (Bronfenbrenner, 1979), nonetheless, family and peer microsystems have been found to be the most common proximal processes to a student's development (Taylor & Clayton, 2004; Muss, 1996). This study hypothesized that there would be direct effects with the proposed ecological latent constructs on the development of Latino science identity, with peer influence having the largest effect. This study finds three direct statistically significant ecological influences (parental school-based engagement, peer network and science classroom environment) in the final science identity model for Latino students. All of these associations were significant predictors in the final model, but a science classroom perception was the strongest predictor, implying that this microsystem plays a bigger role on the development of science identity as compared to family or peer influences.

Science Classroom Environmental Influence The majority of Latino students in this sample held a positive view of their science classroom-learning environment. That is, Latino students agreed that their science teacher valued and listened to students' ideas, treated students with respect, treated every student fairly, believed mistakes in the classroom were OK if students learned and believed all students can be successful. This science classroom perception factor was found to be the most critical relationship with science identity development (science performance, competence and recognition) in this sample. This is consistent with classroom environment literature on the role teachers play in supporting student outcomes (Gilmartin et al., 2006; Kane, 2015; Varelas, Martin &

Kane, 2012; Museus & Vue, 2013; Wooley et al., 2009). This suggests that high school science teachers have a more proximal influence in high school than parents and peers on their science identity development. This is important as Museus and Vue (2013) found that high school teacher-student relationships impact students' educational trajectories beyond high school. Students who perceived teachers to be supportive and held high expectations of them (i.e., teachers praised effort, teachers expected student success in school, teachers were interested in students, etc.) impacted their grade point averages and standardized test scores, which subsequently impacted their college transition (i.e., student expects to attend college, student applied to college). Future research should build from this study to examine ninth grade Latino students and science teacher relationships, and their impact on distal outcomes (e.g., tenth grade advanced science enrollment, intent to purse a science career, college transitions).

A zero-ordered correlation sub-analysis revealed statistically significant positive relationships between classroom perceptions and their science identity. For instance, Latino students who agreed that science teachers value and listen to students' ideas had a strong relationship with their science performance ($P < .001$), competence ($P < .001$), and recognition ($P < .001$). This sub-analysis mirrors a qualitative study conducted by Gilmartin and colleagues (2006) that found students responded positively to both male and female science teachers who were caring, challenging, engaging, passionate, fair and linked science teaching in some concrete way (p. 1001). However, there is limited understanding on the role of science teachers' background characteristics (e.g., teaching experience, gender and racial/ethnic characteristics). Future studies should introduce these backgrounds in future statistical model initial finding indicate that these have been found to influence students' learning outcomes. For instance, Latino students often have teachers who are non-Latino and these teachers make up 93 percent of the teaching profession in secondary schools (Planty, Hussar, Snyder, Kena, KewalRamani, Kemp, Bianco & Dinkes, 2009). Research highlights that teachers from underrepresented groups hold higher expectations for students with similar backgrounds (Romo & Falbo, 1994).

Peer Network Influence Latinos who have a positive peer network were found to be the second most critical relationship with science identity. This study found the majority of Latino students have positive peer networks, in which the majority of them had a close friend who was interested in school, received good grades in school and planned to go to college. Findings from this study compliment and extend current literature on the benefits of having positive peer networks for these Latino students. Overall, peer microsystem directly and indirectly influenced science identity. Peer networks directly impact science identity development, as well as indirectly impact science classroom-learning environment perception, which then influence science identity in a greater magnitude. Peer influence allow for students to connect, engage, value, and develop school-oriented identities (Dennis, Phinney & Chuateco, 2005; Loukas et al., 2006; Garcia-Reid, 2007; Gonzalez & Padilla, 1997; Ream & Rumberger, 2008) that can lead to increased school motivation, college aspirations and greater academic achievement (Gandara, O'Hara & Gutiérrez, 2004). This finding is consistent with previous literature suggesting that students are influenced in greater magnitude by peer support than parental support as they progress through school (See for, example, Bokhorst, Sumter & Westenberg, 2010). This highlights how peer influence can impact their class perceptions.

A zero-ordered correlation revealed statistically significant positive relationships between peer networks and socioeconomic status. Latino students with higher socioeconomic status were more likely to have friends planning to go to college ($p < .001$). This finding is significant as 23 percent of Latino families were found to live at the poverty level (Macartney, Bishaw & Fontenot, 2013). These socioeconomic realities may limit Latino students' opportunities to connect with positive peer networks or encounter institutional agents who may provide valuable college information and resources (Stanton-Salazar, 2001). Together, these results provide additional insights into Latino background characteristics, peer influence and academic outcomes with regards to science. Future research should examine the composition characteristics of positive peer networks (e.g., gender, racial/ethnic, course enrollments, etc.). Latino peer groups have shown to be ethnically segregated from other student groups, and as a result maintain a close-knit community. This may limit their access to information networks and knowledge, as Latinos have been found to be less likely to attend college and/or pursue a STEM occupation (Carnevale et al., 2011; Gandara et al., 2004; Stanton-Salazar, 2001).

Parental School-based Influence Science identity and parental influence was found to be the third most critical relationship. In general, parental involvement has shown to promote positive student achievement (Catsambis, 2001; Henderson & Mapp, 2002; Hill & Tyson, 2009; Museus & Vue, 2013; Woolley et al., 2009). Literature highlights that the parents of Latino students are less likely to be involved with school-based activities due to the differences between the home and school environment (Valencia & Black, 2002). However, recent scholarship claims parental involvement participation does not differ by racial/ethnic backgrounds (Robinson, 2014). In fact, after reviewing three decades of longitudinal surveys, Robinson argues that parental involvement in general does not improve a student's academic grades or test scores. He highlights consistent homework help from parents almost never improves academic outcomes, regardless of parental background characteristics (e.g., social class, racial/ethnic background, education level). The parents of Latino students in this sample had more than three-fourths of the parents attending school meetings, more than half attending parent-teacher conferences, slightly less than half of the parents meeting with a school counselor, and less than one-fourth volunteering at their child's school. Together, these results suggest parents are involved in school-based experiences, and that these experiences influence their child's science identity directly and indirectly.

Furthermore, a zero-ordered correlation analysis revealed that statistically significant positive relationships exist between parents attending school meetings and their child having a close friend who plans to go to college ($p < .001$). Both of these relationships have a positive impact on science recognition and performance. Given this importance, future research should continue to examine data on student, parent and high school settings to discover more robust and inclusive practices to engage parents in school settings. Schools are increasingly expected to partner and collaborate with marginalized families (Ishimaru, Lott, Fajardo & Salvador, 2014); yet, there are limited opportunities to involve parents in school decision-making spaces (Ishimaru, 2014). These practices restrict parents' ability to partner with schools on important school decisions, such as deciding on the school mission, school policy and programming, hiring of new teachers, and influencing science curriculum, all of which may impact their child's educational outcomes, including such as science identity.

Out-of-classroom Science Influence Surprisingly, this study did not find statistically significant direct paths between the out-of-classroom microsystem and science identity in the context of this SEM model. To further understand out-of-classroom science experiences, a zero-ordered correlation was conducted. This sub-analysis revealed Latino students visiting a science/engineering museum had statistically significant positive associations with science identity (e.g., performance, competence and recognition), parental school-based involvement (e.g., attending school meetings, volunteering at school and attending parent-student conferences) and peer networks (e.g., friends get good grades and friends plan to go to college). These correlations are consistent with previous research that has found out-of-classroom science experiences allow students to gain science recognition, competence and performance (Crane, Thiry & Laursen, 2011; NRC, 2009). Future research should collect quantitative data and explore other potential out-of-classroom learning experiences not captured in this study (e.g., visiting a parent's workplace, participating in interactive web applications, etc.). These experiences can advance our understanding of innovative science activities, while examining their impact on educational development outcomes.

Hypothesis 3.a

In this study, statistical differences were found within Latino male and Latina female SEM group comparison models. In particular, differences within perceptions of science classroom-learning environment were noted. Latinas' science classroom perceptions impact their science identity with a larger magnitude compared to Latino males. Research has shown that teachers contribute to gender differences by modeling gender role behaviors, communicating different expectations and encouraging different activities and skills for males and females (Eccles, 1983). The results of this study extend and compliment previous research on Latinas' perception of a positive high school science classroom environment. This highlights the continued need for high school science teachers to provide positive learning environment cues to Latinos in general, but in particular to females (Gilmartin et al, 2006; Eccles, 1983).

Research finds female and male students typically earn similar grades in science classes, yet female students have been shown to have less positive attitudes toward science, tend to score lower on standardized science tests, engage in fewer science-related activities, have lower parental involvement, enroll in fewer science courses during middle and high school and have lower science college major aspirations (Catsambis, 1995; Else-Quest et al., 2013; Gilmartin et al., 2006; Pomerantz et al., 2002; Simkins et al., 2015). Given the differences in science-related outcomes and experiences, an analysis of factor mean scores was conducted by gender. When compared to Latino males, Latina females were found to have statistically significant differences in means for three microsystem latent factors and science identity (See appendix). Latinas had higher parental school-based engagement, positive peer networks and increased out-of-classroom participation compared to Latino males. Yet, Latino male students had higher science identity means compared to female students. Latina female students face "double jeopardy" because they encounter race as well as gender bias in STEM (Williams, Phillips & Hall, 2014). According to Eccles (1983), teachers may contribute to gender differences by modeling gender role behaviors, communicating different expectations and encouraging different activities and skills for males and females.

This sub-analysis reveals a need to focus on classroom environments, as this study found was the most critical relationship to science identity, in order to have a better understanding of the impact on science identity development for Latinas. This finding, along with previous research, highlights the need for Latina female students to receive positive and inclusive messages earlier than high school to directly and indirectly minimize STEM stereotyping, microaggressions and STEM diversion (i.e., derogatory slights and insults) occurring in classrooms, schools or work settings (Ramsey, Betz & Sekaquaptewa, 2013; Suarez-Orozco, Casanova, Martin, Katsiaficas, Cuellar, Smith & Dias, 2015). Current research highlights how Latinas working in STEM fields are often mistaken for administrative or custodial staff (Williams et al., 2014). Microaggression research highlights how these experiences impact higher education and workplace settings, but more research is necessary in secondary schools to further explore this type of experience and its impact on establishing an identity in science.

Hypothesis 3.b

Latinos enrolling in regular or advanced science classes did not have statistical differences in the science identity group comparison model. This finding is not consistent with previous research that suggests differences in Latino student outcomes may be due to advance placement class enrollment (Gandara et al., 2004; Gonzalez, 2013). For instance, Gandara et al., (2004) found that Latino students who are placed in advanced level science classes often benefit from access to a rigorous science curriculum and the ability to connect with other academically successful peers (Gandara et al., 2004). A zero-ordered correlation analysis found a statistically significant relationship with both science recognition and performance ($p < .001$) but not science competence, the most critical component of science identity in this study. In addition, students were more likely to have a close friend interested in school who planned to go to college ($p < .01$).

Hypothesis 3.c

School location group comparison models (i.e. urban, suburban, and town/rural) did not have statistical differences. Previous literature has found that a school's geographic location has a significant effect on student learning outcomes (Gandara et al., 2004; Harper, 2015; Warren et al, 2014). In fact, previous literature found that urban schools have a perception of having non-motivated students of color and parents who are not involved compared to suburban schools (Harper, 2015). This study found that there are no statistical differences by school location, thus suggesting Latino students may be experiencing similar microsystems and mesosystems across school locations. A zero-ordered correlation analysis revealed no statistically significant associations between school location and science performance. Correlational differences were found within science recognition, in which Latino students attending urban schools had a statistically positive association ($p < .05$) and town/rural Latino students had a statistically negative association ($p < .001$). In fact, town/rural had statistically negative relationships with parents attending school meetings ($p < 05$), volunteering at school ($p < .05$), students having a close friend interested in school ($p < .01$) and a close friend planning to go to college ($p < .05$). These correlational results extend Hondo and colleagues' (2008) findings on Latino students attending rural schools in Idaho, in which they found students felt discounted and invisible, leading them to feel marginalized.

Implications for Theory, Research, Policy & Practice

Given the importance of developing a science identity for Latino students as this is a precursor for various academic benefits, such as enrolling in more advanced science courses and pursuing STEM majors, it is imperative that attention be given to all significant ecological factors. This study found critical relationships in a Latino student's life contribute to a positive development of a healthy science identity early in the educational pipeline. These findings have several implications for how educators and policy stakeholders think about engaging and preparing Latino students in order for them to thrive along the science pipeline.

Future policy should reframe the conversation around STEM access by using a diverse set of science benchmarks to monitor science progression in secondary contexts. Science identity is an evolving construct falling along a continuum or multiple continuums, which are different for different groups of students with different sets of experiences and contexts (Gilmartin et al., 2006, p. 982). This dissertation highlights that theoretical scholars, policymakers and educators should recognize the value in developing and studying non-cognitive factors, such as science identities for Latino students, and not solely depend on science performance measures (e.g., test scores and science grades) toward deciding if students are proficient or capable of being successful in science early in the educational pipeline. There is a need to use a diverse set of science-related benchmarks along the pipeline, such as science performance, recognition and competence. These science identity benchmarks can begin to provide a comprehensive understanding for how students develop and how multifaceted ecologies influence their ability to thrive in science.

The Next Generation Science Standards are the latest science standards to be implemented in the United States. They aim to ensure all students, regardless of language or background, master three science dimensions: content, scientific and engineering practices, and cross-cutting concepts (NGSS, 2013). These standards will impact students' science performance (i.e., science grade earned). There is a need to understand science curriculum's role in developing science identity for students. Current literature highlights a limited understanding of how standards improve students' science outcomes. For instance, Lerner and colleagues (2012) examined how rigorous each state covered physical science, life science, earth and space science, scientific inquiry and methodology. They found that only 6 states earned an 'A grade' for quality science standards while 27 states received a 'D' or 'F'. Most states did not hold students and teachers accountable for learning or did not provided teachers with the right instructional tools to improve achievement (Lerner et al., 2012). Therefore, future research should examine science curricula (e.g., NGSS) in order to understand the impact on a student's science performance and science identity and its impact on academic outcomes.

Competence (e.g., self-efficacy) in STEM subjects has been shown to be vital to Latino student success (Museus et al, 2011). Yet, educational research continues to surround Latino students with deficient discourses (Harper, 2015). Latino students are often labeled as disinterested in school or to have limited science content knowledge. Latino deficit discourse often leads to educational practices focusing on basic skills rather than offering science content-rich learning (Spillane, Diamond, Walker, Halverson & Loyiso, 2001). The ability to have confidence in science assignments, exams and classes may be impacted by deficient practices. In fact, Suarez-Orozco and colleagues (2015) found that nearly 30 percent of community college classrooms displayed microaggressions in their sample. Microaggressions were directed toward underrepresented and gender status students, creating hostile learning experiences. Intelligence, cultural/racial, gendered and intersectional microaggressions were commonly found in these classes. Future research should examine microaggressions in secondary contexts in order uncover classroom environments that foster these attitudes to avoid invalidation and hostile environments.

To develop a diverse science community, Latino students will need to be able to see themselves as scientists through recognition from teachers, students, STEM mentors and the broader community. Kane (2015) argues, "The goal of science educators is not simply to teach scientific concepts and practices, but also to offer students avenues to see themselves as people who can do science and see science as a way to engage with the world so they might find their own place in it and make their own contributions" (p. 21). One way to do this is to increase Latino students' enrollment in advanced science classes, recruit and hire Latino teachers and connect Latino STEM workers to Latino students (Brown et al., 2015). These strategies begin to create environments that welcome Latino male and female students from diverse cultural backgrounds (Brown et al, 2015), thus allowing them to see themselves as future scientists and as a valued part of the learning community.

This study explored the relationship between multiple high school influences and science identity development for an underrepresented STEM student population in high school. Microsystems and mesosystems used in this study highlight how parents, peers and science classroom learning environments play a vital role in building Latino students' science identity. This study provides evidence for how researchers and practitioners can apply an integrated ecological framework to their own unique institutional populations and settings when examining academic outcomes. Educators can examine academic messages from various microsystems and create strategies for how to equip direct influences with information on how to build a science identity throughout the educational pipeline, encourage and support inclusive science practices, and prepare all students towards postsecondary and STEM career options. This will provide students with the opportunity to decide their career path when they are ready and not limit. Additionally, Saenz and Ponjuan (2011) highlight key high school practices that support Latino students, including:

1. Emotional Support—Encourage caring and respect through mentoring, peer support and individual counseling.
2. Instrumental Support—Offer tangible interventions, such as workshops focused on financial literacy, study skills and time management.
3. Informational Support—Offer valuable information related to academic transitions, academic advising and career choices.
4. Appraisal Support—Offer ongoing feedback based on student progress.
5. Structural Support—Provide formal and informal structures to improve the school's culture and climate (p. 14).

Conclusion

This research applied CFA and SEM to examine high school's direct and indirect ecological influences on Latino students' science identity. A few ecological influences were explored through an anti-deficient lens, guided by Bronfenbrenner's Ecological

Model and Carlone and Johnson's Science Identity Framework to cultivate ninth grade science trajectories of Latino students. Literature finds that there are many barriers that keep Latinos from identifying and succeeding in STEM-related careers along the STEM pipeline. This research highlights a need for Latino students to engage early in the science learning process though strengthened science content knowledge, competence and recognition. This will increase Latino representation and success within the science pipeline. Findings from this study provide tremendous insight into three statistically significant ecological influences (i.e. parental, peer and science classroom). These results are useful for educators seeking integrate or strengthen science identity practices in high school environments.

References

ACT (2013). The Condition of College & Career Readiness. Retrieved from: http://www.act.org/research/policymakers/cccr13/readiness1.html

Adelman, C. (2006). The toolbox revisited: Paths to degree completion from high school through college. Washington, DC: U.S. Department of Education.

Alfaro, E. C., Umaña-Taylor, A. J., & Bámaca, M. Y. (2006). The Influence of Academic Support on Latino Adolescents; Academic Motivation. *Family Relations*, 55, 3, 279-291.

American Association for the Advancement of Science (1989). Chapter 1: The Nature Of Science. Retrieved from: http://www.project2061.org/publications/sfaa/online/chap1.htm

American Council on Education. (1937). The student personnel point of view: A report of a conference on the philosophy and development of student personnel work in college and university, 1, 3.

Anderson, E. L. & Kim, D. (2006). *Increasing the success of minority students in science and technology.* Washington, D.C.: American Council on Education.

Arellano, A. R., & Padilla, A. M. (1996). Academic invulnerability among a select group of Latino university students. Hispanic Journal of Behavioral Sciences, 18, 4.

Aschbacher, P. R., Li, E., & Roth, E. J. (2010). Is Science Me? High School Students' Identities, Participation and Aspirations in Science, Engineering, and Medicine. *Journal of Research in Science Teaching*, 47, 5, 564-582

Bahena, S., In Cooc, N., & In Currie-Rubin, R. (2012). *Disrupting the school-to-prison pipeline.* Cambridge, Massachusetts: Harvard Educational Review.

Baker, J. A. (1999). Teacher-student interaction in urban at-risk classrooms: Differential behavior, relationship quality, and student satisfaction with school. *The Elementary School Journal*, 100, 1, 57-70.

Bandura, A. (1986). *Social foundations of thought and action: A social cognitive theory*. Englewood Cliffs, NJ: Prentice Hall.

Basham, J. D., Israel, M., & Maynard, K. (2010). An ecological model of STEM education: operationalizing STEM for all. *Journal of Special Education Technology*, *25*, 3, 9.

Beaton, A. E. (1996). Science achievement in the middle school years: IEA's Third International Mathematics and Science Study (TIMSS). Chestnut Hill, MA: TIMSS International Study Center, Boston College.

Beede, D., Julian, T., Khan, B., Lehrman, R., McKittrick, G., Langdon, D., & Doms, M. (2011). Education supports racial and ethnic equality in STEM. *Economics and Statistics Administration Issue Brief*, (05-11).

Bender, S. (1994). Female student career aspirations in science. Saskatchewan School Trustees Association. Research Centre Report #94-04.

Bensimon, E. M. (2005). Equality as a fact, equality as a result: A matter of institutional accountability. Washington, DC: American Council of Education.

Bensimon, E. M., & Dowd, A. (2010). Dimensions of the Transfer Choice Gap: Experiences of Latina and Latino Students Who Navigated Transfer Pathways. *Harvard Educational Review*, 79, 4, 632-658.

Bokhorst, C. L., Sumter, S. R., & Westenberg, P. M. (2010). Social Support from Parents, Friends, Classmates, and Teachers in Children and Adolescents Aged 9 to 18 Years: Who Is Perceived as Most Supportive?. *Social Development*, 19, 2, 417-426.

Bonous-Hammarth, M. (2000). Pathways to success: Affirming opportunities for science, mathematics, and engineering majors. *Journal of Negro Education*, 92-111.

Brickhouse, N. W., & Potter, J. T. (2001). Young Women's Scientific Identity Formation in an Urban Context. *Journal of Research in Science Teaching*, 38, 8, 965-80.

Bronfenbrenner, U. (1979). The ecology of human development: Experiments by nature and design. Cambridge, Mass: Harvard University Press.

Bronfenbrenner, U. (1993). The ecology of cognitive development: Research models and fugitive findings. In R. H. Wozniak & K. Fischer (Eds.), Scientific environments (pp. 3–44). Hillsdale, NJ: Erlbaum.

Bronfenbrenner, U. (1994). Ecological models of human development. In T. Husen & T. N. Postlethwaite (Eds.), International encyclopedia of education (2nd ed., Vol. 3, pp. 1643–1647). Oxford, England: Pergamon Press/ Elsevier Science.

Bronfenbrenner, U. (1995). Developmental ecology through space and time: A future perspective. In P. Moen, G. H. Elder Jr., & K. Lüscher (Eds.), Examining lives in context: Perspectives on the ecology of human development (pp. 619–648). Washington, DC: American Psychological Association.

Bronfenbrenner, U. (2005). Making human beings human: Bioecological perspectives on human development. Thousand Oaks: Sage Publications

Bronfenbrenner, U., & Evans, G. W. (2000). Developmental science in the 21st century: Emerging questions, theoretical models, research designs, and empirical findings. Social Development, 9, 1, 15–25.

Bronfenbrenner, U., & Morris, P. A. (1998). The ecology of developmental processes. In R. M. Lerner (Ed.), Handbook of Child Psychology (5th ed., Vol. 1, pp. 993–1028). New York: Wiley.

Bronfenbrenner, U., & Morris, P. A. (2006). The bioecological model of human development. In W. Damon & R. M. Lerner (Eds.), Handbook of child psychology, Vol. 1: Theoretical models of human development (6th ed., pp. 793 – 828). New York: Wiley.

Brown, B. (2004). Discursive identity: Assimilation into the culture of science and its implications for minority children. *Journal of Research in Science Teaching*, 41, 810–834.

Brown, T. A. (2006). *Confirmatory factor analysis for applied research*. New York: Guilford Press.

Brown, B. A., Henderson, J. B., Gray, S., Donovan, B., Sullivan, S., Patterson, A., & Waggstaff, W. (2015). From description to explanation: An empirical exploration of the African-American pipeline problem in STEM. *Journal of Research in Science Teaching*.

Carlone, H.B., & Johnson, A. (2007). Understanding the science experiences of successful women of color: Science identity as an analytic lens. *Journal of Research in Science Teaching*, *44*, 8, 1187–1218.

Carnevale, A. P., Smith, N., & Melton, M. (2011). STEM: Science, Technology, Engineering, Mathematics. Center for Education and the Workforce, Georgetown University.

Catsambis, S. (1995). Gender, race, ethnicity, and science education in the middle grades. *Journal of Research in Science Teaching*, 32, 243–257.

Catsambis, S. (2001). Expanding knowledge of parental involvement in children's secondary education: Connections with high school seniors' academic success. *Social Psychology of Education*, 5, 149-177.

Ceja, M. (2004). Chicana college aspirations and the role of parents: Developing educational resiliency. *Journal of Hispanic Higher Education*, 3, 4, 1-25.

Chang, M. J., Cerna, O., Han, J., & Sáenz, V. (2008). The contradictory roles of institutional status in retaining underrepresented minorities in biomedical and behavioral science majors. *The Review of Higher Education, 31*(4), 433-464.

Cheryan, S., Master, A., & Meltzoff, A. N. (2015). Cultural Stereotypes as Gatekeepers: Increasing Girls' Interest in Computer Science and Engineering by Diversifying Stereotypes. *Frontiers in Psychology*, *6*, 49.

Chen, X., & Weko, T. (2009). Students Who Study Science, Technology, Engineering, and Mathematics (STEM) in Postsecondary Education. Stats in Brief. US Department of Education (NCES 2009-161).

Cobb, P. (2004). Mathematics, literacies, and identity. *Reading Research Quarterly*, 39, 333–337.

Cole, S. E. (2012). *The development of science identity: An evaluation of youth development programs at the museum of science and industry, chicago* (Order No. 3550537). Available from ProQuest Dissertations & Theses Global. (1286700113). Retrieved from http://search.proquest.com/docview/1286700113?accountid=14784

Committee on STEM Education National Science and Technology Council (2013). Committee on STEM Education, The Federal Science, Technology, Engineering and Mathematics Education Portfolio, Washington, D.C. National Science Technology Council.

Contreras, F. (2011). *Achieving equity for Latino students: Expanding the pathway to higher education through public policy*. New York: Teachers College Press.

Correll, S. J. (2001). Gender and the Career Choice Process: The Role of Biased Self-Assessments. *American Journal of Sociology*, 106, 1691-1730.

Crane, R., Thiry, H., & Laursen, S. (April 2011). Broadening the view: First steps toward mapping the national landscape of out-of- school-time science education. Presented at Inciting the Social Imagination: Education Research for the Public Good, Annual Meeting of the American Educational Research Association, New Orleans, LA.

Crisp, G., Nora, A, & Taggart, A. (2009). Student characteristics, pre-college, college, and environmental factors as predictors of majoring in and earning a STEM degree: An analysis of students attending a Hispanic serving institution. The American Educational Research Journal, 46, 924–942.

Crowley, K., Callanan, M. A., Tenenbaum, H. R.,&Allen, E. (2001). Parents explain more often to boys than to girls during shared scientific thinking. *Psychological Science,* 12, 3, 258–261.

Cvencek, D., Meltzoff, A. N., & Greenwald, A. G. (2011). Math-gender stereotypes in elementary school children. Child Development, 82, 3.

Darling-Hammond, L. (2000). Teacher quality and student achievement: A review of state policy evidence. *Educational Policy Analysis Archives*, 8, 1.

Darling, N., Caldwell, L. L., & Smith, R. (2005). Participation in school-based extracurricular activities and adolescent adjustment. *Journal of Leisure Research*, *37*, 1, 51-76.

Delgado-Gaitan, C. (1991). Involving parents in the schools: A process of empowerment. *American journal of Education*, 20-46.

Dowd, A. C., Malcom, L. E., and Bensimon, E. M. (2009). Benchmarking the success of Latina and Latino students in STEM to achieve national graduation goals. Los Angeles: University of Southern California.

DeWitt, J., Osborne, J., Archer, L., Dillon, J., Willis, B., & Wong, B. (2013). Young Children's Aspirations in Science: The unequivocal, the uncertain and the unthinkable. *International Journal of Science Education*, 35, 6, 1037-1063.

Dierking, L. D., Falk, J. H., Rennie, L., Anderson, D., & Ellenbogen, K. (2003). Policy statement of the "informal science education" ad hoc committee. *Journal of Research in Science Teaching,* 40, 2, 108-111.

Dimitrov, D. M. (2006). Comparing groups on latent variables: a structural equation modeling approach. *Work (Reading, Mass.)*, *26*, 4, 429–36.

Duschl, R. A., Schweingruber, H. A., & Shouse, A. W. (2007). Taking science to school. Learning and teaching science in grades K-8. Washington, DC: National Academies Press.

Eccles, J. S., Jacobs, J. E., & Harold, R. D. (1990). Gender role, stereotypes, expectancy effects, and parents' socialization of gender differences. *Journal of Social Issues*, 46, 183–201

Eccles, J. (1983). Female achievement patterns: Attributions, expectancies, values, and choice. *Journal of Social Issues,* 1-26.

Eccles, J. S., & Wigfield, A. (2002). Motivational beliefs, values, and goals. *Annual Review of Psychology, 53*, 1, 109-132.

Else-Quest, N. M., Mineo, C. C., & Higgins, A. (2013). Math and science attitudes and achievement at the intersection of gender and ethnicity. *Psychology of Women Quarterly*, 37, 293–309.

Ensminger, M. E., Lamkin, R. P., & Jacobson, N. (1996). School Leaving: A Longitudinal Perspective Including Neighborhood Effects. *Child Development*, 67, 5, 2400-2416.

Espinosa, L.L. (2011). Pipelines and pathways: Women of color in undergraduate STEM majors and the college experiences that contribute to persistence. *Harvard Educational Review, 81*, 2, 209-240.

Evans, N. J., Forney, D. S., Guido, F. M., Patton, L. D., & Renn, K. A. (2010). *Student development in college: Theory, research, and practice*. San Francisco: Jossey-Bass.

Farrington, C.A., Roderick, M., Allensworth, E., Nagaoka, J., Keyes, T.S., Johnson, D.W., & Beechum, N.O. (2012). Teaching adolescents to become learners. The role of noncognitive factors in shaping school performance: A critical literature review. Chicago: University of Chicago Consortium on Chicago School Research.

Flores, A. (2007). Examining disparities in mathematics education: Achievement gap or opportunity gap?. *The High School Journal*, *91*, 1, 29-42.

Flores-Gonzalez, N. (2002). *School kids/street kids: Identity development in Latino students*. Teachers College Press.

Fraser, B. J. (1991). Two decades of classroom environment research. In B. J. Fraser & H. J. Walberg (Eds.), Educational environments: Evaluation, antecedents, and consequences (pp. 3-27). Oxford: Pergamon.

Fraser, B. J., & Walberg, H. J. (1991). *Educational environments: Evaluation, antecedents, and consequences*. Oxford: Pergamon Press.

Frederickson, N., & Petrides, K. V. (2008). Ethnic, gender, and socio-economic group differences in academic performance and secondary school selection: A longitudinal analysis. *Learning and Individual Differences*, *18*, 2, 144-151.

Gandara, P. C., & Contreras, F. (2009). *The Latino education crisis: the consequences of failed social policies*. Cambridge, Mass.: Harvard University Press.

Gándara, P., O'Hara, S., & Gutiérrez, D. (2004). The changing shape of aspirations: Peer influence on achievement behavior. In Gibson, M. A., Gándara, P., & Koyama, J. P. (Eds.) *School Connections: U.S. Mexican Youth, Peers, and School Achievement*. New York, NY: Teachers College Press.

Garcia-Reid, P. (2007). Examining Social Capital as a Mechanism for Improving School Engagement Among Low Income Hispanic Girls. *Youth & Society*, 39, 2, 164-181.

Gee, J. P. (2000). Identity as an Analytic Lens for Research in Education. *Review of Research in Education*, 25, 1, 99-125.

Gibson, M. A., Gandara, P. C., & Koyama, J. P. (2004). *School connections: U.S. Mexican youth, peers, and school achievement*. New York: Teachers College Press.

Gilmartin, S.K., Li, E., & Aschbacher, P. (2006). The relationship between interest in physical science/engineering, science class experiences, and family contexts: Variations by gender and race/ethnicity among secondary students. *Journal of Women and Minorities in Science and Engineering,* 12, 179–207.

Gimbert, B., Bol, L., & Wallace, D. (2007). The Influence of Teacher Preparation on Student Achievement and the Application of National Standards by Teachers of Mathematics in Urban Secondary Schools. Education and Urban Society, 40, 1, 91-117.

Gloria, A. M., & Rodriguez, E. R. (2000). Counseling Latino university students: Psychosociocultural issues for consideration. *Journal of Counseling and Development, 78*, 2, 145-154.

Gonzalez, J. (2013). Understanding the Role of Social Capital and School Structure on Latino Academic Success. LUX: A Journal of Transdisciplinary Writing and Research from Claremont Graduate University: 2, 1, 16. Retrieved from: http://scholarship.claremont.edu/lux/vol2/iss1/16

González, R., & Padilla, A. M. (1997). The academic resilience of Mexican American high school students. Hispanic Journal of Behavioral Sciences, 19, 301-317.

Griffith, A. L. (2010). Persistence of women and minorities in STEM field majors: Is it the school that matters?. *Economics of Education Review,* 29, 6.

Gunderson, E. A., Levine, S. C., Levine, S. C., & Beilock, S. L. (2012). New Directions for Research on the Role of Parents and Teachers in the Development of Gender-Related Math Attitudes: Response to Commentaries. *Sex Roles*, 66, 3-4.

Hackett, G., Betz, N. E., Casas, J. M., & Rocha-Singh, I. A. (1992). Gender, ethnicity, and social cognitive factors predicting the academic achievement of students in engineering. *Journal of Counseling Psychology*, *39*, 4, 527.

Hamre, B. K., & Pianta, R. C. (2007). Learning opportunities in preschool and early elementary classrooms. In Pianta, R. C., Cox, M. J., & Snow, K. L. B. (2007). School readiness and the transition to kindergarten in the era of accountability. (pp. 49-84). Baltimore, Md: Paul H. Brookes Pub.

Hanushek, E. A., Kain, J. F., Markman, J. M., & Rivkin, S. G. (2003). Does peer ability affect student achievement?. *Journal of applied econometrics*, *18*, 5, 527-544.

Hardré, P. L., Crowson, H. M., Debacker, T. K., & White, D. (2007). Predicting the academic motivation of rural high school students. *The Journal of Experimental Education*, *75*, 4, 247-269.

Harper, S. R. (2007). Using qualitative methods to assess student trajectories and college impact. *New Directions for Institutional Research*, 136, 55-68.

Harper, S. (2010). An anti-deficit achievement framework for research on students of color in STEM. New Directions for Institutional Research, 2010,148, 63-74.

Harper, S. (2015). Success in These Schools? Visual Counternarratives of Young Men of Color and Urban High Schools They Attend. *Urban Education*, 50, 2, 139-169.

Henderson, A., & Mapp, K. (2002). A new wave of evidence: The impact of school, family, and community connections on student achievement. Austin, TX:

National Center for Family & Community Connections with Schools/Southwest Educational Development Laboratory.

Herrera, F. A. & Hurtado, S. (2011). *Maintaining initial interests: Developing science, technology, engineering, and mathematics (STEM) career aspirations among underrepresented racial minority students*. Los Angeles: Higher Education Research Institute.

Higher Education Research Institute. (2010). Degrees of success: Bachelor's degree completion rates among initial STEM majors. Los Angeles: Higher Education Research Institute.

Hill, N. E., & Torres, K. (2010). Negotiating the American Dream: The Paradox of Aspirations and Achievement among Latino Students and Engagement between their Families and Schools. *Journal of Social Issues*, 66, 1, 95-112.

Hill, N. & Tyson, D. (2009). Parental involvement in middle school: analytic assessment of the strategies that promote achievement. *Developmental Psychology, 45, 3,* 760-763.

Ho, E. S. C. (2010). Family influences on science learning among Hong Kong adolescents: What we learned from PISA. *International Journal of Science and Mathematics Education*, 8, 3, 409-428.

Hondo, C., Gardiner, M. E., & Sapien, Y. (2008). Latino dropouts in rural America: Realities and possibilities. Albany: State University of New York Press.

Howard, J., & Hammond, R. (1985). Rumors of inferiority. *The New Republic, 193,* 17–21.

Hu, L., & Bentler, P. M. (1999). Cutoff criteria for fit indexes in covariance structure analysis: Conventional criteria versus new alternatives. *Structural Equation Modeling: A Multidisciplinary Journal*, *6*, 1, 1–55.

Ingels, S.J., and Dalton, B. (2013). *High School Longitudinal Study of 2009 (HSLS:09) First Follow-up: A First Look at Fall 2009 Ninth-Graders in 2012* (NCES 2014-360). U.S. Department of Education. Washington, DC: National Center for Education Statistics.

Ingels, S.J., Pratt, D.J., Herget, D.R., Burns, L.J., Dever, J.A., Ottem, R., Rogers, J.E., Jin, Y., and Leinwand, S. (2011). *High School Longitudinal Study of 2009 (HSLS:09). Base-Year Data File Documentation* (NCES 2011-328). U.S. Department of Education. Washington, DC: National Center for Education Statistics. Retrieved June 2014 from http://nces.ed.gov/pubsearch

Irvine, J. J. (1990). *Black students and school failure: Policies, practices, and prescriptions*. New York: Greenwood Press.

Ishimaru, A. M. (2014). Rewriting the Rules of Engagement: Elaborating a Model of District-Community Collaboration. Harvard Educational Review, 84, 2, 188-216.

Ishimaru, A. M., Lott, J., Fajardo, I., & Salvador, J. (2014). Towards Equitable Parent-School Collaboration: Developing Common Parent Engagement Indicators (White Paper). Equitable Parent-School Collaboration Research Project, Seattle, WA: University of Washington.

Jacobs, J.E., Davis-Kean, P., Bleeker, M., Eccles, J.S. & Malanchuk, O. (2005). I can, but I don't want to: The impact of parents, interests, and activities on gender differences in math. In A. Gallagher & J. Kaufman (Ed.), *Gender Differences in Mathematics* (p. 246-263). Cambridge University Press.

Kane, J. M. (2015). Young African American boys narrating identities in science. *Journal of Research in Science Teaching*, 1-24.

Katsinas, S. G., & Hardy, D. E. (2012). Rural community college: Promoting access and building sustainable regional rural innovation. In J. Smart (Ed.), Higher education: Handbook of theory and research (Vol. 27). New York, NY: Agathon Press.

Kline, R. (2005). *Principles and practice of structural equation modeling*. New York: Guilford Press.

Kline, R. (2011). *Principles and Practice of Structural Equation Modeling,* Third Edition. New York: Guilford Press.

Landivar, L. C. (2013). Disparities in STEM Employment by Sex, Race, and Hispanic Origin. *American Community Survey Reports*, ACS-24, U.S. Census Bureau, Washington, DC.

Lee, J. (2002). Racial and ethnic achievement gap trends: Reversing the progress toward equity? *Educational Researcher*, 31, 1, 3-12.

Lerner, L. S., Goodenough, U., Lynch, J., Schwartz, M., & Schwartz, R. (2012). *The state of the state science standards*. Washington, DC: Thomas B. Fordham Institute.

Leslie, L.L., McClure, G.T., & Oaxaca, R.L. (1998). Women and minorities in science and engineering: A life sequence analysis. *The Journal of Higher Education, 69*, 3, 239-276.

Li, Y., Lynch, A., Kalvin, C., Liu, J., & Lerner, R. (2011). Peer relationships as a context for the development of school engagement during early adolescence. *International Journal of Behavioral Development,* 35, 329-342.

Loehlin, J. C. (2004). *Latent variable models: an introduction to factor, path, and structural equation analysis*. Mahwah, N.J.: L. Erlbaum Associates.

Lopez, E. M. (2001). Guidance of Latino High School Students in Mathematics and Career Identity Development. *Hispanic Journal of Behavioral Sciences*, *23*, 2, 189–207.

Loukas, A., Suzuki, R., & Horton, K. D. (2006). Examining school connectedness as a mediator of school climate effects. *Journal of Research on Adolescence*, 16, 491-502.

Lowell, B. L., & Salzman, H. (2007). Into the eye of the storm: Assessing the evidence on science and engineering education, quality, and workforce demand. Retrieved from http:// www.urban.org/publications/411562.html

Lu, C. (2013). STEM (ming) Up from Niños to Científicos. Dissertation. Retrieved from: http://repositories.lib.utexas.edu/handle/2152/21845

Macartney, S., Bishaw, A., & Fontenot, K. (2013). *Poverty rates for selected detailed race and Hispanic groups by state and place: 2007–2011. American Community Survey Brief, 11-17*. Washington, DC: U.S. Census Bureau.

May, G. S., & Chubin, D. E. (2003). A retrospective on undergraduate engineering success for underrepresented minority students. *Journal of Engineering Education*, 92, 1, 27-39.

Malecki, C. K., & Demaray, M. K. (2007). Social Support as a Buffer in the Relationship between Socioeconomic Status and Academic Performance. *School Psychology Quarterly*, 21, 4, 375-395.

Martinez, C. R., DeGarmo, D. S., & Eddy, J. M. (2004). Promoting Academic Success Among Latino Youths. *Hispanic Journal of Behavioral Sciences*, 26, 2, 128-151.

McComas, W. F. E. (2006). Science Teaching beyond the Classroom. *Science Teacher*, 73, 1, 26-30.

Mena, J. A. (2011). Latino parent home-based practices that bolster student academic persistence. *Hispanic Journal of Behavioral Sciences*, *33*, 4, 490-506.

Murphy, M. C., Steele, C. M., & Gross, J. J. (2007). Signaling Threat: How Situational Cues Affect Women in Math, Science, and Engineering Settings. Psychological Science, 18, 10, 879-885.

Muss, R. E. (1996). *Theories of adolescence*. New York, NY: McGraw-Hill.

Nasr, K., Pennington, J., & Andres, C. (2004). A study of students' assessments of cooperative education outcomes. *Journal of Cooperative Education, 38*, 1, 13-21.

Nasir, N., Jones, A., & McGlaughlin, M. (2011). School connectedness for students in urban high schools. *Teachers College Record*, 113, 1755–1793.

National Center for Education Statistics (2012). The Nation's report card: Science 2011 (NCES 2012–465). Institute of Education Sciences, U.S. Department of Education, Washington, D.C

National Academies, National Academy of Sciences, National Academy of Engineering, and Institute of Medicine. (2010). *Expanding underrepresented minority* *participation: America's science and technology talent at the crossroads.* Washington, DC: National Academies Press.

National Science Foundation, National Center for Science and Engineering Statistics. (2013). Women, minorities, and persons with disabilities in science and engineering: 2013. Special Report NSF 13-304. Arlington, VA. Retrieved from http://www.nsf.gov/statistics/wmpd/

National Research Council. (2009). *Learning science in informal environments: People, places, and pursuits.* Washington, DC: National Academies Press.

National Research Council. (2012). A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas. Committee on a Conceptual Framework for New K-12 Science Education Standards. Board on Science Education, Division of Behavioral and Social Sciences and Education. Washington, DC: The National Academies Press.

Nelson, R. M., & DeBacker, T. K. (2009). Achievement Motivation in Adolescents: The Role of Peer Climate and Best Friends. *Journal of Experimental Education*, 76, 2, 170-189.

Next Generation Science Standards (2013). Science Education in the 21st Century Why K–12 Science Standards Matter—and why the time is right to develop. Retrieved from: http://www.nextgenscience.org/sites/ngss/files/NGSS%20fact%20sheet.pdf

Nord, C., Roey, S., Perkins, R., Lyons, M., Lemanski, N., Brown, J., and Schuknecht, J. (2011). The Nation’s Report Card: America’s High School Graduates (NCES 2011-462). U.S. Department of Education, National Center for Education Statistics. Washington, DC: U.S. Government Printing Office.

Oakes, J., & Wells, A. S. (1998). Detracking for High Student Achievement. *Educational Leadership*, 55, 6, 38-41.

Okpala, C. O., Okpala, A. O., & Smith, F. E. (2001). Parental Involvement, Instructional Expenditures, Family Socioeconomic Attributes, and Student Achievement. *Journal of Educational Research,* 95, 2, 110-15.

Pajares, F. (2005). Gender differences in mathematics self-efficacy beliefs. In A. M. Gallagher & J. C. Kaufman (Eds.), Gender differences in mathematics: An integrative psychological approach (pp. 294–315). New York: Cambridge University Press.

Patricia, A. P., & Patricia, M. M. D. (2008). Understanding Latina and Latino College Choice: A Social Capital and Chain Migration Analysis. *Journal of Hispanic Higher Education*, 7, 3, 249-265.

Perera, L. D. H., Bomhoff, E. J., Grace, H.Y. (2014). Parents' Attitudes Towards Science and their Children's Science Achievement. *International Journal of Science Education,* 1-21.

Perna W.L., and Titus, M.A. (2005). The relationship between parental involvement as social capital and college enrollment: An examination of racial/ethnic group differences. *The Journal of Higher Education,* 76, 5, 485-518

Planty, M., Hussar, W., Snyder, T., Kena, G., KewalRamani, A., Kemp, J., Bianco, K., Dinkes, R. (2009). *The Condition of Education 2009* (NCES 2009-081). National Center for Education Statistics, Institute of Education Sciences, U.S. Department of Education. Washington, DC.

Plunkett, S. W., & Bámaca-Goméz, M. Y. (2003). The relationship between parenting, acculturation, and adolescent academics in Mexican-origin immigrant families in Los Angeles. *Hispanic Journal of Behavioral Sciences*, 25, 222-239.

Pomerantz, E. M., Altermatt, E. R., & Saxon, J. L. (2002). Making the Grade but Feeling Distressed: Gender Differences in Academic Performance and Internal Distress. *Journal of Educational Psychology*, 94, 2, 396-404.

Provasnik, S., Kastberg, D., Ferraro, D., Lemanski, N., Roey, S., and Jenkins, F. (2012). *Highlights From TIMSS 2011: Mathematics and Science Achievement of U.S. Fourth- and Eighth-Grade Students in an International Context* (NCES 2013-009 Revised). National Center for Education Statistics, Institute of Education Sciences, U.S. Department of Education. Washington, DC

Ramsey, L. R., Betz, D. E., & Sekaquaptewa, D. (2013). The effects of an academic environment intervention on science identification among women in STEM. *Social Psychology of Education*, 16, 3, 377-397.

Ratelle, C. F., Larose, S., Guay, F., & Sene´cal, C. (2005). Perceptions of parental involvement and support as predictors of college students' persistence in a scientific curriculum. *Journal of Family Psychology,* 19, 286 –293.

Renn, K. A. (2003). Understanding the Identities of Mixed-Race College Students through a Developmental Ecology Lens. *Journal of College Student Development*, 44, 3, 383-403

Riegle-Crumb, C. (2006). The Path through Math: Course Sequences and Academic Performance at the Intersection of Race-Ethnicity and Gender. *American Journal of Education,* 113, 1, 101-123.

Riegle-Crumb, C., Moore, C., & Ramos-Wada, A. (2011). Who Wants to Have a Career in Science or Math? Exploring Adolescents' Future Aspirations by Gender and Race/Ethnicity. *Science Education*, 95, 3, 458-476.

Robinson, K. (2014). *The broken compass: Parental involvement with children's education*.

Roderick, M. (2003). What's happening to the boys? Early high school experiences and school outcomes among African American male adolescents in Chicago. *Urban Education*, 38, 538-607.

Romo, H. D., & Falbo, T. (1994). *Latino high school graduation: Defying the odds*. Austin, TX: University of Texas Press.

Rumberger, R.W. & Thomas, S.L. (2000). The distribution of dropout and turnover rates among urban and suburban high schools. *Sociology of Education*, 73, 39-67.

Russell, M. L., & Atwater, M. M. (2005). Traveling the road to success: A discourse on persistence throughout the science pipeline with Black students at a predominantly white institution. *Journal of Research in Science Teaching, 42*, 6, 691-715.

Sadker, M., & Sadker, D. M. (1994). *Failing at fairness: How America's schools cheat girls.* New York: Scribner.

Saenz, V. B., & Ponjuan, L. (2009). The Vanishing Latino Male in Higher Education. *Journal of Hispanic Higher Education*, 8, 1, 54–89.

Sass, D. A. (2011). Testing Measurement Invariance and Comparing Latent Factor Means Within a Confirmatory Factor Analysis Framework. *Journal of Psychoeducational Assessment*, 29, 4, 347-363.

Schreiber, J. B., Nora, A., Stage, F. K., Barlow, E. A., & King, J. (2006). Reporting Structural Equation Modeling and Confirmatory Factor Analysis Results: A Review. *Journal of Educational Research*, 99, 6, 323-337.

Sedlacek, W. E. (2005). The case for noncognitive measures. In W. Camara & E. Kimmel (Eds.). *Choosing students: Higher education admission tools for the 21st century*. (pp. 177-193). Mahwah, NJ: Lawrence Erlbaum.

Sinclair, S., Hardin, C. D., & Lowery, B. S. (2006). Self-stereotyping in the context of multiple social identities. *Journal of Personality and Social Psychology*, 90, 4, 529-42.

Singh, K., Granville, M., & Dika, S. (2002). Mathematics and Science Achievement: Effects of Motivation, Interest, and Academic Engagement. *Journal of Educational Research,* 95, 6, 323-32.

Simpkins, S. D., Price, C. D., & Garcia, K. (2015). Parental support and high school students' motivation in biology, chemistry, and physics: Understanding differences among Latino and Caucasian boys and girls. *Journal of Research in Science Teaching*.

Smith, F. M., & Hausafus, C. O. (1998). Relationship of Family Support and Ethnic Minority Students' Achievement in Science and Mathematics. *Science Education*, 82, 1, 111-25.

Stanton-Salazar, R. D. (2001). *Manufacturing hope and despair: the school and kin support networks of U.S.-Mexican youth*. New York: Teachers College Press.

Stout, J. G., Dasgupta, N., Hunsinger, M., & McManus, M. (2011). STEMing the tide: Using in group experts to inoculate women's self-concept and professional goals in science, technology. *Journal of Personality and Social Psychology*, 100, 255–270.

Strayhorn, T. L. (2009). Different folks, different hopes: The educational aspirations of Black males in urban, suburban, and rural high schools. *Urban Education*, 44, 710-731.

Steele, C. M. (1997). A threat in the air. How stereotypes shape intellectual identity and performance. *The American Psychologist*, 52, 6, 613-29.

Steele, C. M., & Aronson, J. (1995). Stereotype threat and the intellectual test performance of African Americans. *Journal of Personality and Social Psychology*, 69, 5, 797-811.

Suarez-Orozco, C., Casanova, S., Martin, M., Katsiaficas, D., Cuellar, V., Smith, N. A., & Dias, S. I. (2015). Toxic Rain in Class: Classroom Interpersonal Microaggressions. *Educational Researcher*, 44, 3, 151-160.

Sun, L., Bradley, K. D., & Akers, K. (2012). A multilevel modeling approach to investigating factors impacting science achievement for secondary school students: PISA Hong Kong sample. *International Journal of Science Education*, *34*, 14, 2107-2125.

Sung, H., Padilla, A. M., & Silva, D. M. (2006). Foreign Language Education, Academic Performance, and Socioeconomic Status: A Study of California Schools. *Foreign Language Annals*, 39, 1, 115-130.

Supple, A. J., Ghazarian, S. R., Frabutt, J. M., Plunkett, S. W., & Sands, T. (2006). Contextual Influences on Latino Adolescent Ethnic Identity and Academic Outcomes. *Child Development, 77,* 5, 1427-1433.

Szechter, L. E., & Carey, E. J. (2009). Gravitating toward Science: Parent-Child Interactions at a Gravitational-Wave Observatory. *Science Education,* 93, 5, 846-858.

U.S. Census Bureau (2010). The Hispanic Population: 2010. Washington, DC: U.S. Government Printing Office.

Tai, R. T., Liu, C. Q., Maltese, A. V., Fan, X. T. (2006). Planning early for careers in science. *Science*, 312 5777, 1143-1144.

Thomas, D. E., & Stevenson, H. C. (2009). Gender risks and education: The particular classroom challenges for urban low-income African American boys. *Review of Research in Education,* 33, 160-180.

Torres, T., Jones, S. R., & Renn, K. A. (2009). Identity Development Theories in Student Affairs: Origins, Current Status, and New Approaches. *Journal of College Student Development,* 50, 6, 577-596.

Tyson, W., Lee, R., Borman, K. M., & Hanson, M. A. (2007). Science, Technology, Engineering, and Mathematics (STEM) Pathways: High School Science and Math Coursework and Postsecondary Degree Attainment. *Journal of Education for Students Placed at Risk,* 12, 3, 243-270.

Valadez, J. R. (2002). The influence of social capital on mathematics course selection by Latino high school students. *Hispanic Journal of Behavioral Sciences*, 24, 319-339.

Valenzuela, Y. (2006). *Mi fuerza/my strength. the academic and personal experiences of Chicana/Latina transfer students in math and science* (Order No. 3243278).

Available from ProQuest Dissertations & Theses Global. (304916976). Retrieved from http://search.proquest.com/docview/304916976?accountid=14784

Van de Schoot, R., Lugtig, P., & Hox, J. (2012). A checklist for testing measurement invariance. European *Journal of Developmental Psychology*, 9, 4, 486-492.

Venezia, A., & Jaeger, L. (2013). Transitions from high school to college. *The Future of Children*, *23*, 1, 117-136.

Wagstaff, I. R. (2014). *Predicting 9th graders' science self-efficacy and STEM career intent: A multilevel approach* (Order No. 3584390). Available from ProQuest Dissertations & Theses Global. (1554724318). Retrieved from http://search.proquest.com/docview/1554724318?accountid=14784

Walker, E. N. (2012). *Building mathematics learning communities: Improving outcomes in urban high schools*. New York, NY: Teachers College Press.

Walton, G. M., & Cohen, G. L. (2007). A question of belonging: race, social fit, and achievement. *Journal of Personality and Social Psychology,* 92, 1, 82-96.

Warren, J. R., Hoffman, E., & Andrew, M. (2014). Patterns and Trends in Grade Retention Rates in the United States, 1995-2010. *Educational Researcher*, 43, 9, 433-443.

Watt, H. M. G. (2006). The role of motivation in gendered educational and occupational trajectories related to math. *Educational Research and Evaluation*, 12, 305–322.

Wheelock, A., & Massachusetts Advocacy Center (1992). *Crossing the tracks: How untracking can save America's schools.* New York: The New Press.

Wicherts, J. M. and C. V. Dolan (2010). Measurement invariance in confirmatory factor analysis: An illustration using IQ test performance of minorities. *Educational Measurement: Issues and Practice* 29, 3, 39-47.

Williams, C., J., Phillips, W. K., & Hall, V. E. (2014). Double Jeopardy? Gender bias against women of color in Science. The Center for WorkLife Law.

Woolley, M. E., Kol, K. L., & Bowen, G. L. (2009). The Social Context of School Success for Latino Middle School Students: Direct and Indirect Influences of Teachers, Family, and Friends. *Journal of Early Adolescence*, 29, 1, 43-70.

Yaeger, R. (1996). *Science-Technology-Society: As Reform in Science Education*. Albany, NY: State University of New York Press.

Zhou, M. (2003). Urban education: Challenges in educating culturally diverse children. *Teachers College Record*, 105, 208-225.

Zuniga, K., Olson, J. K., & Winter, M. (2005). Science Education for Rural Latino/a Students: Course Placement and Success in Science. *Journal of Research in Science Teaching*, 42, 4, 376-402.

Appendices

Appendix A. Independent Variable Definitions and Coding Schemes

Latent Variable	Measured Variable	Variable Coding
Background Influence		
	Socioeconomic status	HSLS:09 computed five-item composite: (1) mothers education level, (2) fathers education level, (3) mothers occupation, (4) fathers occupation, and (5) family income.
Parental Influence		
	School meeting	Since the start of 2009-2010 school year, parent attended a general school meeting on a dichotomous: 0 = no and 1 = yes.
	Parent-teacher conferences	Since the start of 2009-2010 school year, parent attended parent-teacher conference on a dichotomous scales: 0 = no and 1 = yes.
	School volunteer	Since the start of 2009-2010 school year, parent served as a school volunteer on a dichotomous scales: 0 = no and 1 = yes.
	Met with counselor	Since the start of 2009-2010 school year, parent met with a school counselor on a dichotomous scales: 0 = no and 1 = yes.
Peer Science Influence		
	Closest friend gets good grades	Dichotomous: 0 = False and 1 = True.
	Closest friend is interested in school	Dichotomous: 0 = False and 1 = True.
	Closest friend plans to go to college	Dichotomous: 0 = False and 1 = True.

Science Classroom Influence		
	Science teacher values/listens to students' ideas	4-point scale: ninth grade's perception ranging from "Strongly disagree" to "Strongly agree."
	Science teacher treats students with respect	4-point scale: ninth grader's perception ranging from "Strongly disagree" to "Strongly agree."
	Science teacher treats every student fairly	4-point scale: ninth grader's perception ranging from "Strongly disagree" to "Strongly agree."
	Science teacher thinks all student can be successful	4-point scale: ninth grader's perception ranging from "Strongly disagree" to "Strongly agree."
	Science teacher thinks mistakes are OK if students learn	4-point scale: ninth grader's perception ranging from "Strongly disagree" to "Strongly agree."
Out-of-classroom science Influence		
	Science/engineering museum	Since the past school year, parent went to science or engineering museum with ninth grader on a dichotomous scale: 0 = no and 1 = yes.
	Worked/played on a computer	Since the past school year, parent worked or played on computer with ninth grader on a dichotomous scale: 0 = no and 1 = yes.
	Science project	Since the past school year, parent worked on a science project with ninth grader on a dichotomous: 0 = no and 1 = yes.
	Science fair	Since the past school year, parent attended a school science fair with ninth grade
	Library	Since the past school year, parent visited a library with ninth grader on a dichotomous: 0 = no and 1 = yes.

Appendix B. Comparison Variable Definitions

Comparison groups	Measured Variable	Variable coding
Student level		
	Student's gender	Ninth grader's gender on a dichotomous: 0 = male and 1 = female.
	Science classroom enrollment	Ninth grader's most advanced ninth grade science course enrollment on a dichotomous: 0 = regular science class (e.g., General science, earth science, integrated science I, life science, and physical science) and 1 = advanced science class (e.g., Physics, advanced physics, biology, advanced biology, other biology, and chemistry).
School level		
	School location	Urban location = 0, Suburban location = 1, Rural/Town = 2.

Appendix C. Science Identity Composite Items for All Ninth Grade Latinos

		Min.	Max.	Mean	SD
Science Recognition					
	Ninth grader sees himself/herself as a science person	0	3	1.19	0.88
	Others see ninth grader as a science person	0	3	1.11	0.82
Science Competence					
	Ninth grader certain can understand current science textbook	0	3	1.55	0.78
	Ninth grader certain can master skills in current science class	0	3	1.79	0.72
	Ninth grader confident they can do an excellent job on their science assignments	0	3	1.90	0.70
	Ninth grader confident they can do an excellent job on their science tests	0	3	1.76	0.74

Appendix D. Descriptive Statistics by Latino Gender

		Male (n = 800)		Female (n = 857)	
Latent Variable	**Measured Variable**	**Mean**	**SD**	**Mean**	**SD**
Science Identity					
	Science recognition	1.18	0.80	1.12	0.76
	Science competence	1.82	0.62	1.69	0.62
	Science performance	3.70	1.08	3.87	1.03
Background influence					
	Socioeconomic status	-0.42	0.72	-0.36	0.73
Parental influences					
	Attends school meetings	0.75	0.43	0.76	0.43
	Attends school conferences	0.56	0.50	0.55	0.50
	Volunteers at school	0.23	0.42	0.25	0.43
	Met with a school counselor	0.46	0.50	0.41	0.49
Peer Influences					
	Friend gets good grades	0.83	0.38	0.87	0.33
	Friend is interested in school	0.64	0.48	0.72	0.45
	Friend plans to go to college	0.85	0.35	0.90	0.30
Science classroom Influence					
	Teacher values/listens to students' ideas	2.13	0.72	2.13	0.68
	Teacher treats students with respect	2.24	0.68	2.25	0.66
	Teacher treats every student fairly	2.17	0.75	2.15	0.71
	Teacher thinks all student can be successful	2.29	0.69	2.26	0.65
	Teacher thinks mistakes are OK if students learn	2.11	0.72	2.14	0.66
Out-of-classroom science influence					
	Science/engineering museum	0.47	0.50	0.52	0.50
	Worked or played on computer	0.78	0.42	0.81	0.39
	Worked on a science project	0.19	0.39	0.22	0.42
	Attended a science fair	0.46	0.50	0.47	0.50
	Visited a library	0.60	0.49	0.69	0.46
Comparison					
	Advanced science class	0.48	0.50	0.52	0.50
	Location: Urban	0.31	0.46	0.32	0.47
	Location: Suburban	0.36	0.48	0.37	0.48
	Location: Town/Rural	0.34	0.47	0.31	0.46

Appendix E. Descriptive Statistics by Science Enrollment

		Regular (*n* = 781)		Advanced (*n* = 876)	
Latent Variable	**Measured Variable**	**Mean**	**SD**	**Mean**	**SD**
Science Identity					
	Science recognition	1.12	0.77	1.23	0.81
	Science competence	1.74	0.62	1.76	0.63
	Science performance	3.68	1.06	3.96	1.01
Background Influence					
	Socioeconomic status	-0.40	0.71	-0.29	0.75
Parental Science Influence					
	Attends school meetings	0.74	0.44	0.79	0.41
	Attends school conferences	0.56	0.50	0.57	0.49
	Volunteers at school	0.24	0.43	0.27	0.44
	Met with a school counselor	0.42	0.49	0.45	0.50
Peer Science Influence					
	Friend gets good grades	0.85	0.36	0.86	0.35
	Friend is interested in school	0.65	0.48	0.70	0.46
	Friend plans to go to college	0.88	0.33	0.90	0.29
Science Classroom Influence					
	Teacher values/listens to students' ideas	2.08	0.70	2.17	0.70
	Teacher treats students with respect	2.21	0.68	2.28	0.66
	Teacher treats every student fairly	2.11	0.75	2.21	0.71
	Teacher thinks all student can be successful	2.24	0.68	2.30	0.67
	Teacher thinks mistakes are OK if students learn	2.10	0.69	2.15	0.69
Out-of-classroom science Influence					
	Science/engineering museum	0.49	0.50	0.53	0.50
	Worked or played on computer	0.79	0.41	0.83	0.38
	Worked on a science project	0.20	0.40	0.22	0.41
	Attended a science fair	0.47	0.50	0.47	0.50
	Visited a library	0.65	0.48	0.65	0.48
Comparison Groups:					
	Student's gender: Female	0.48	0.50	0.52	0.50
	Location: Urban	0.26	0.44	0.34	0.48
	Location: Suburban	0.40	0.49	0.37	0.48
	Location: Town/Rural	0.34	0.47	0.29	0.45

Appendix F. Descriptive Statistics by School Location

		Urban (*n* = 522)		Suburban (*n* = 643)		Town/Rural (*n* = 493)	
Latent Variable	**Measured Variable**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**
Science Identity							
	Science recognition	1.20	0.76	1.18	0.79	1.08	0.79
	Science competence	1.78	0.61	1.78	0.62	1.70	0.63
	Science performance	3.84	1.04	3.78	1.08	3.74	1.05
Background							
	Socioeconomic status	-0.33	0.80	-0.33	0.71	-0.51	0.64
Parental							
	Attends school meetings	0.78	0.41	0.77	0.42	0.72	0.45
	Attends school conferences	0.59	0.49	0.53	0.50	0.54	0.50
	Volunteers at school	0.28	0.45	0.22	0.42	0.21	0.41
	Met with a school counselor	0.46	0.50	0.42	0.49	0.42	0.49
Peer							
	Friend gets good grades	0.84	0.37	0.86	0.35	0.85	0.36
	Friend is interested in school	0.71	0.45	0.68	0.47	0.65	0.48
	Friend plans to go to college	0.89	0.32	0.89	0.31	0.86	0.35
Science Classroom							
	Teacher values/listens to students' ideas	2.15	0.67	2.11	0.71	2.12	0.71
	Teacher treats students with respect	2.28	0.66	2.24	0.65	2.23	0.70
	Teacher treats every student fairly	2.21	0.69	2.14	0.74	2.15	0.76
	Teacher thinks all student can be successful	2.31	0.64	2.24	0.69	2.28	0.68
	Teacher thinks mistakes are OK if students learn	2.11	0.70	2.13	0.66	2.12	0.70
Out-of-classroom							
	Science/engineering museum	0.52	0.50	0.52	0.50	0.45	0.50
	Worked or played on computer	0.79	0.41	0.81	0.40	0.78	0.41
	Worked on a science project	0.23	0.42	0.18	0.38	0.21	0.41
	Attended a science fair	0.46	0.50	0.47	0.50	0.47	0.50
	Visited a library	0.66	0.47	0.66	0.47	0.60	0.49
Comparison							
	Student's gender: Female	0.51	0.50	0.51	0.50	0.48	0.50
	Advanced science class	0.59	0.49	0.50	0.50	0.48	0.50

Appendix G. Latent Factor Correlation Matrix

	Min.	Max.	*M*	*SD*	1.	2.	3.	4.	5.
1. Science Identity	-1.39	0.99	0.00	0.15	--				
2. Parental	-0.48	0.40	0.00	0.15	.38	--			
3. Peer	-0.51	0.15	0.00	0.12	.46	.36	--		
4. Out-of-class	-0.46	0.38	0.00	0.14	.35	.78	.26	--	
5. Science Classroom	-2.09	0.77	0.00	0.47	.44	.09	.25	.07	--

Note. N=1658.

Appendix H. Gender Mean Differences on Latent Factors

Latent Factor	Estimate	Standard Error	p-value
Science identity	-0.035	0.012	**
Parental influence	0.013	0.005	**
Peer influence	0.024	0.004	***
Out-of-classroom influence	0.026	0.005	***
Science classroom learning environment influence	0.002	0.015	

Male is the reference group.

Appendix I. Correlation Matrix of Measured Variables and Science Identity Components

	1	2	3	4	5	6	7	8	9	10	11
1. Science recognition	--										
2. Science competence	0.48***	--									
3. Science performance	0.28***	0.33***	--								
4. Socioeconomic status	0.13***	0.15***	0.27***	--							
5. School meetings	0.06***	0.02	0.14***	0.24***	--						
6. School conferences	0.03	0.02	0.00	0.19***	0.28***	--					
7. Volunteers at school	0.03*	0.10***	0.12***	0.23***	0.23***	0.22***	--				
8. Met with a school counselor	0.03*	0.03	-0.04	0.17***	0.16***	0.24***	0.16***	--			
9. Friends get good grades	0.06***	0.10***	0.14***	0.09***	0.03	0.04	0.06***	0.02	--		
10. Friends is interested in school	0.12***	0.13***	0.14***	0.00	0.01	0.02	0.07***	0.01	0.38***	--	
11. Friends plans to go to college	0.09***	0.11***	0.19***	0.15***	0.10***	0.05*	0.06***	0.06	0.31***	0.30***	--
12. Values/listens to students' ideas	0.17***	0.30***	0.13***	0.03	0.00	0.05*	0.06**	-0.02	0.10***	0.12***	0.08***
13. Treats students with respect	0.13***	0.24***	0.09***	0.01	-0.02	0.01	0.05*	-0.02	0.05***	0.10***	0.06***
14. Treats every student fairly	0.14***	0.25***	0.10***	0.03	0.00	0.01	0.05*	-0.02	0.03***	0.10***	0.04***
15. All students can be successful	0.13***	0.26***	0.10***	-0.01	-0.01	0.03	0.04	-0.04	0.08*	0.10***	0.08***
16. Mistakes are OK if students learn	0.14***	0.23***	0.08***	0.02	0.00	0.02	0.06*	-0.02	0.07***	0.11***	0.08***
17. Science/engineering museum	0.11***	0.09***	0.08***	0.16***	0.13***	0.11***	0.11***	0.09***	0.03***	0.03	0.05*
18. Worked/played on a computer	0.03*	0.01	0.09***	0.16***	0.11	0.07***	0.07***	0.09***	0.09	-0.01*	0.03
19. Worked on a science project	0.06*	0.01	0.03*	0.02	0.12	0.11***	0.09***	0.08***	0.01	0.05	0.08
20. Attended a science fair	0.06*	0.00	0.03*	0.03	0.13	0.16***	0.15***	0.07***	0.00	0.03*	0.06*
21. Visited a library	0.08**	0.06**	0.06*	0.02	0.13	0.07***	0.14***	0.07***	0.03	0.03	0.05

Notes: 1 = student science recognition, 2 = science competence, 3 = science performance, 4 = socioeconomic status, 5 = parent attends school meetings, 6 = parent attends school conferences, 7 = parent volunteers at school, 8 = parent met with a school counselor, 9 = friends get good grades, 10 = friend is interested in school, 11 = friend plans to go to college, 12 = science teacher values/listens to students' idea, 13 = science teacher treats students with respect, 14 = science teacher treats every student fairly, 15 = science teacher thinks all students can be successful, 16 = science teacher thinks mistakes are OK if students learn, 17 = student visited a science/engineering museum, 18 = student worked/played on a computer, 19 = student worked on a science project, 20 = student attended a science fair, and 21 = student visited a library.

* $p < .05$, **$p < .01$, *** $p < .001$

Appendix I. *Continued*

	12	13	14	15	16	17	18	19	20	21
1. Science recognition										
2. Science competence										
3. Science performance										
4. Socioeconomic status										
5. School meetings										
6. School conferences										
7. Volunteers at school										
8. Met with a school counselor										
9. Friends get good grades										
10. Friends is interested in school										
11. Friends plans to go to college										
12. Values/listens to students' ideas	--									
13. Treats students with respect	0.71***	--								
14. Treats every student fairly	0.70***	0.78***	--							
15. All students can be successful	0.63***	0.68***	0.68***	--						
16. Mistakes are OK if students learn	0.56***	0.57***	0.55***	0.55***	--					
17. Science/engineering museum	0.01	0.01	0.03	0.01	0.00	--				
18. Worked/played on a computer	0.01	0.00	0.02	0.04	0.00	0.14***	--			
19. Worked on a science project	0.01	-0.01	-0.01	-0.01	0.01	0.15***	0.13***	--		
20. Attended a science fair	0.02	0.03	0.02	0.03	0.02	0.20***	0.09***	0.32***	--	
21. Visited a library	0.01	0.03	0.03	0.03	0.03	0.27***	0.14***	0.14***	0.20***	--

Notes: 1 = student science recognition, 2 = science competence, 3 = science performance, 4 = socioeconomic status, 5 = parent attends school meetings, 6 = parent attends school conferences, 7 = parent volunteers at school, 8 = parent met with a school counselor, 9 = friends get good grades, 10 = friend is interested in school, 11 = friend plans to go to college, 12 = science teacher values/listens to students' idea, 13 = science teacher treats students with respect, 14 = science teacher treats every student fairly, 15 = science teacher thinks all students can be successful, 16 = science teacher thinks mistakes are OK if students learn, 17 = student visited a science/engineering museum, 18 = student worked/played on a computer, 19 = student worked on a science project, 20 = student attended a science fair, and 21 = student visited a library.

* $p < .05$, ** $p < .01$, *** $p < .001$

Appendix J. Results of Full SEM Science Identity Model

Path	Total	Direct	Indirect
Socioeconomic status --> Parental engagement influence	0.48***	0.48***	-
Parental engagement influence --> Peer network influence	0.25***	0.25***	-
Socioeconomic status --> Peer network influence	0.12***	-	0.12***
Parental engagement influence --> Out-of-classroom science influence	0.56***	0.56***	-
Socioeconomic status --> Out-of-classroom science influence	0.27***	-	0.27***
Parental engagement --> Science classroom learning environment influence	0.04***	-	0.04***
Socioeconomic status --> Science classroom learning environment influence	0.02***	-	0.02***
Peer network influence --> Science classroom learning environment influence	0.18***	0.18***	-
Socioeconomic status --> Science identity	0.12***	-	0.12***
Parental engagement influence --> Science identity	0.24***	0.14*	0.10***
Peer network influence --> Science identity	0.26***	0.20***	0.06***
Science classroom learning environment influence --> Science identity	0.32**	0.32***	-
Out-of-classroom science influence --> Science identity	0.07	0.07	-

Note: * $p < .05$, ** $p < .01$, *** $p < .001$. Dash (-) indicates no path.

Appendix K. Tests of Invariance in Nested Models: Latino male and female students

Model	**X^2**	**df**	**Δ X^2**	**Δ df**	**AIC**	**RMSEA**	**CFI**	**SRMR**
Configural (Baseline)	696.975	354			48648.663	0.034	0.957	0.037
Metric invariance (Equal factor loadings)			23.386	15	48642.049	0.034	0.956	0.039

Appendix L. Tests of Invariance in Nested Models: Regular and advanced science enrollment

Model	**X^2**	**df**	**ΔX^2**	**Δ df**	**AIC**	**RMSEA**	**CFI**	**SRMR**
Configural (Baseline)	677.056	354			48654.784	0.033	0.96	0.037
Metric invariance (Equal factor loadings)			18.469	15	48643.252	0.033	0.959	0.039

Appendix M. Tests of Invariance of Factor Structure for Latinos Attending Urban, Suburban, and Rural/Town

Model	**X^2**	**df**	**Δ X^2**	**Δ df**	**AIC**	**RMSEA**	**CFI**	**SRMR**
Configural (Baseline)	970.56	531			48726.853	0.039	0.946	0.044
Metric invariance (Equal factor loadings)			55.169	30	48722.019	0.039	0.943	0.047

Appendix N. Comparison of Paths Across Male and Female Students

Path	Male Estimates			Female Estimates		
	Total	**Direct**	**Indirect**	**Total**	**Direct**	**Indirect**
Socioeconomic status --> Parental influence	0.51***	0.51***	-	0.45***	0.45***	-
Parental influence --> Peer network	0.23**	0.23**	-	0.25***	0.25***	-
Socioeconomic status --> Peer network	0.12***	-	0.12***	0.11***	-	0.11**
Parental influence --> Out-of-classroom	0.58***	0.58***	-	0.534**	0.54***	-
Socioeconomic status --> Out-of-classroom	0.30***	-	0.30***	0.24***	-	0.24***
Parental influence --> Science classroom environment	0.05***	-	0.05***	0.04**	-	0.04**
Socioeconomic status --> Science classroom environment	0.02**	-	0.02**	0.02*	-	0.02*
Peer network --> Science classroom environment	0.21***	0.21***	-	0.15**	0.15**	-
Socioeconomic status --> Science identity	0.12***	-	0.12***	0.11***	-	0.11***
Parental influence --> Science identity	0.23*	0.08	0.15***	0.26***	0.15	0.11***
Peer network --> Science identity	0.33***	0.28***	0.05***	0.25**	0.20**	0.05**
Science classroom environment --> Science identity	0.28***	0.28**	-	0.36***	0.36***	-
Out-of-classroom science --> Science identity	0.13	0.13	-	0.08	0.08	-

Note: * p < .05, **p < .01, *** p < .001. Dash (-) indicates no path.