Science aspirations of urban Latino students: A study in East Los Angeles, California



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ABSTRACT

Latinos are now the largest racial and ethnic minority group in the United States. However, despite the size of the population, Latinos have historically been underrepresented in the sciences. While interventions have been implemented across the U.S. in order to raise aspirations towards a future in the sciences, the proportion of Latino youth choosing to enter the science pipeline remains low. This suggests that intervention programs designed generally might not take into account important factors influencing Latino science aspirations specifically. This study systematically investigated factors that impact the science aspirations of U.S. Latinos in secondary school (ages 11 to 14), filling a gap in knowledge and addressing a critical section of the 'science pipeline' from middle school to high school. Survey data was collected from a sample of 539 6th grade science and 428 9th grade science students attending six public middle schools and five public high schools in East Los Angeles, California. More than nine in ten of the students were Latino, reflecting the demographic composition of the neighbourhood schools. This thesis details science aspirations among this group of students, analysing variation according to gender, home language use, immigration generation, and socioeconomic status. Predictors of science aspirations included attitudinal constructs generated from survey data by principal components analyses. The results of hierarchical multivariate regression analyses suggest that most of these students were detached from science, their science aspirations strongly influenced by family, school experiences, and neighbourhood conditions. Comparisons of results show significant differences in science aspirations by age and gender: the 6th grade students held significantly higher science aspirations than the 9th grade students; 9th grade girls held the lowest science aspirations. Post analysis teacher interviews and an extended 6th grade sample provide valuable context for the results of the survey analyses. The results and findings are discussed in relation to sociocultural theories which stress the structuring effect of U.S. society on aspirations. The main contribution to knowledge of this study was to establish a detailed understanding of the influences on the science aspirations and science-related attitudes of urban Latino youth, based on empirical data from a large and representative East Los Angeles sample.

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CHAPTER 1 INTRODUCTION

The demographic makeup of the United States (U.S.) has changed dramatically in the last half-century. For example, the Latino population has grown to the point where it is now the majority group in the largest state in the U.S. – California. Yet, even as the U.S. Latino population has grown, the group continues to lag behind most other ethnic groups on many measures of educational achievement, attainment, and participation, particularly in the STEM fields. Given U.S. society's demand for a consistent talent pipeline to the STEM fields, the shifting demographics of the state and ongoing Latino underattainment in science education motivate this research. More specifically, this study explored the science aspirations and science-related attitudes of secondary school students in East Los Angeles, with the overarching aim of contributing to the understanding of participation in the STEM fields in California.

This chapter establishes the background, context, and importance of this study into Latino science aspirations and attitudes. This chapter begins by providing an overview of demographics and public education pertinent to this study. Next, Latino STEM participation in California is examined. Then, the context of this study, East Los Angeles, is explored. Following, an overview of the study is presented. Lastly, a summary of the thesis structure is detailed.

1.1 Recent changes in demographics and public education in the U.S.

1.1.1 Changing demographics in the U.S.

When the Civil Rights Act was passed in 1964, the U.S. population was approximately 90% White and 9% Black (or African American), with the remaining small proportion some "other" race (U.S. Census Bureau, 1964). In the ensuing five decades, the demographic composition of the United States changed dramatically: by 2014 more than a third of the U.S. population considered itself to be a race or ethnicity other than White (U.S. Census Bureau, 2014). For example, the size of the Latino population has increased to the point where they are now the largest ethnic minority group in the U.S., having surpassed African-Americans just after the 2000 U.S. decennial census (U.S. Census Bureau, 2010); an increase resulting from

decades of in-migration from Latin America, particularly the nation of Mexico. To clarify, an ethnic Latino, according to the U.S. Office of Management and Budget, refers to a person of Cuban, Mexican, Puerto Rican, South or Central American (other than Guyana, French Guiana, and Suriname), or other Spanish culture or origin regardless of race (U.S. Census Bureau, 2010). In terms of race, the U.S. Census Bureau uses six categories: White, Black or African-American, American Indian or Alaska Native, Asian, Native Hawaiian or Other Pacific Islander, and Some Other Race (U.S. Census Bureau, 2010).

1.1.2 Ethnic classification of Latinos

Historically, Latinos have been officially categorized as an ethnic group – Hispanic – by the U.S. government (U.S. Census Bureau, 2010). Note, however, that the ethnic category Hispanic[1] encompasses a diverse group of people, people with distinct experiences of the U.S. That is to say, a fourth-generation Californian of Mexican descent is unlikely to have had precisely the same life experiences as a first-generation Cuban immigrant living in Florida. Nonetheless, most Latinos are thought to have more in common with each other than with other ethnic or racial groups (e.g., Flores-Gonzalez, Aranda, & Vaquera, 2014; Hill & Torres, 2010). For example, Flores-Gonzalez et al. (2014) suggest that the daily experiences of Latinos in the U.S. are quite different to that of Whites and, in most cases, are also different to that of Blacks or Asians. In this way, a separate racial identity ("brown") is imposed upon Latinos, as "the racial exclusion these youth experience informs their general understanding of their place, and their marginal belonging, in U.S. society" (Flores-Gonzalez et al., 2014, p. 1848). Further, in their study of Latino youth racial identities, Flores-Gonzalez et al. (2014) found that most of the participants in their study "consider themselves to be part of a racial group rather than an ethnic group, as the U.S. Census designates them" (p. 1834). Consequently, some suggest that the term "ethnorace", a term that captures both ethnic and racial groups, most appropriately categorizes Latinos (e.g., Flores-Gonzalez et al., 2014). However, as the majority of the literature reviewed in Chapter 2 refer to Latinos as an ethnic group, this thesis will utilize the term Latino as an ethnic category.

[1] Henceforth referred to as Latinos in this thesis.

1.1.3 Latino demographics in the U.S.

In the late 1960s there were approximately six million Latinos in the United States, about 4% of the population[2]; they were concentrated in specific regions such as New York and the states bordering Mexico (Pew Hispanic Center, 2013). By 2010, there were more than 50 million Latinos spread throughout the United States, making up 16 percent of the total population (U.S. Census Bureau, 2010)[3]. Importantly, "over half of the growth in the total population of the United States between 2000 and 2010 was due to the increase in the Latino population" (U.S. Census Bureau, 2011, p. 3)**.** The nearly tenfold increase in the Latino population was due largely to in-migration from Latin American countries, particularly Mexico (Pew Hispanic Center, 2012). Consequently, the largest group of Latinos currently living in the U.S. self-identify as being of Mexican origin and comprise about 65% (33 million) of all U.S. Latinos. By comparison, Puerto Ricans, at 9% or 4.5 million, are the next largest segment of the U.S. Latino population (Pew Hispanic Center, 2012).

Note that Latinos are not the only group contributing to the ongoing demographic shifts occurring within the United States. For example, migration from Asian nations to the United States is also substantial, resulting in a rapidly growing proportion of Americans with Asian descent (U.S. Census Bureau, 2014). However, while both Asian and Latino population proportions have increased in recent years, they have experienced the U.S. differently, particularly with regard to educational outcomes. For instance, in 2012 the percentage of 24- to 29-year-old Asian-Americans having attained at least a bachelor's degree was 52.5%, compared with just 13.5% of Latinos in the same age group – different by almost a factor of four (U.S. Census Bureau, 2014). While differences in attainment between Latino and other ethnic and racial minorities are topics of interest and concern in the U.S., research to date has not clearly established which factors underpinning gaps in educational attainment are of greatest significance.

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[2] While Latinos have a long history of residence in the U.S., there was no systematic effort to count them as a separate group until the late 20th century (U.S. Census Bureau, 2011).

[3] The shift in demographics in the U.S. is particularly remarkable in Los Angeles County and this is discussed in Section 1.3.

1.1.4 Public education and educational outcomes in the U.S.

Education in the United States has long been considered a critical pathway to economic opportunity at the individual level (e.g., Bowles & Gintis, 1976; Katznelson & Weir, 1985). Widespread and mandatory government-provided primary and secondary education for all Americans – known as "public school" education in the United States – took hold in the late 19th Century under the influence of the Progressive Movement, with John Dewey a principal figure (e.g., Dewey, 1916). Yet it was not until well into the second half of the 20th Century that the principle of equal public education for Americans of all racial and ethnic backgrounds was articulated: the U.S. Supreme Court decision *Brown v. Board of Education* (1954) declared racially segregated public education unconstitutional. However, another decade would pass before the practice of equal access to public education would have statutory authority with the passage of federal legislation, and in particular, the Civil Rights Act of 1964.

In the fifty years since racial discrimination in public education has been officially prohibited, racial and ethnic minorities have had improved access to educational opportunities in the United States (Barton & Coley, 2010). Nevertheless, gaps in educational attainment between non-Latino Whites and two of the largest racial and ethnic minority groups in the United States – Latinos and African Americans – remain both large and persistent (see Section 2.2). It is now well established that gaps in educational attainment have important long-term effects on economic opportunity, as well as impacting social and political equality (e.g., Hill & Torres, 2010; Tienda, 2009); consequently, it is a topic of great interest in educational research. The majority of research into educational attainment gaps in the United States addresses "Black-White" gaps, with less systematic research focused on Latinos (e.g., Tienda, 2009). The relatively limited amount of research into Latino attainment gaps is owed to recent patterns of in-migration and the subsequent population growth of Latinos, as well as the recent introduction of the ethnic category of "Hispanic/Latino" to the U.S. racial taxonomy in 1980 (U.S. Census Bureau, 2011). The presence and persistence of White-Latino educational attainment gaps offers a clear rationale for a systematic study of aspirations among Latino students in the United States. In particular, educational gaps within science, technology, engineering, and mathematics (STEM) fields motivate this study.

1.2 Latino STEM field participation in California

Business, education, and political leaders in the state of California, and the wider U.S. context, have consistently expressed concerns that there is insufficient "talent" entering into the STEM fields, "talent" necessary to remain globally competitive in the future (e.g., Education Commission of the States, 2019). Of course, a pool of potential STEM talent exists today in the school-age (ages 5 to 18, pre-university) population of California. The largest school-age demographic in California currently is the ethnic Latino group, consisting of about 50% (3.3 million) of the total school-age California population (U.S. Census Bureau, 2014). Thus, it follows that understanding current and future STEM field participation in California requires an understanding of the current state of Latino attainment in STEM.

1.2.1 Latino underattainment in the STEM fields

A brief examination of education attainment rates by ethnicity suggest a pattern of under-participation vis-à-vis the changing demographics presented above. For example, among the over-25 population, the Latino percentage of first university degree attainment (13%) is less than half that of Whites (31%) and less than a third that of Asians (50%) (U.S. Census Bureau, 2012). Within the STEM fields, a wider gap between Whites and Latinos is observed: as a percentage of all degrees earned, the proportion of Whites attaining a first STEM degree is 63%, whereas Latinos make up just 8% of the total (National Science Foundation, 2012b)[4].

It must be noted that Latinos are not the only group considered to be underattaining in U.S. education. Further, the existence of these educational attainment gaps in the U.S. has prompted a considerable amount of research. For example, numerous studies examining educational gaps in STEM attainment by gender suggest early school years are a key stage in the formation of science aspirations (e.g., Maltese & Tai, 2010; Riegle-Crumb, Moore, & Ramos-Wada, 2011; Sorge, 2007). Thus, it is reasonable to think that research into gaps in STEM attainment by ethnicity could usefully explore early sections of the STEM pipeline to university such as, for example, secondary school years.

[4] These statistics are detailed and described more fully in Section 2.2 of this thesis.

1.2.2 Secondary school science in Los Angeles

The sciences are broadly categorized as life sciences and physical sciences at the pre-university level in the U.S. Policy in the Los Angeles Unified School District (LAUSD), the largest school district in the state of California, dictates that students in high school first study biology (a life science) in 9th grade, followed by chemistry (a physical science), and then physics (a physical science) (Los Angeles Unified School District, 2011). However, in order to fulfil the science graduation requirement for high school, LAUSD requires only that a student complete one course in the life sciences and one course in the physical sciences[5] (LAUSD, 2011). As a result, a student can fulfil graduation requirements in two years and stop studying science – never have formally studied chemistry or physics. This is notable, as it has been argued by some science education researchers that enrolment and achievement in high school chemistry and physics courses are particularly important for students aspiring to and subsequently obtaining a STEM degree[6] (e.g., Tai, Liu, Maltese, & Fan, 2006; Tyson, Lee, Borman, & Hanson, 2007). Thus, and while recognising that it is but one factor influencing future STEM participation, examining students' school science experiences is an appropriate starting point for understanding the underattainment and underrepresentation of Latinos in STEM fields. That is to say, it is reasonable to think that a youth's desire to participate in STEM fields in the future will, to some extent, be shaped by science-related attitudes and aspirations formed in pre-university school years. Researching Latino science-related attitudes and aspirations formed in pre-university school years, however, requires an appropriate context.

1.3 The setting of the study: East Los Angeles

1.3.1 Overview of Latino demographics in Los Angeles County

This study was situated in the county of Los Angeles (LA), California, U.S.; it is one of 58 counties in the state of California. Los Angeles was annexed by the United States (along with

[5] It is also possible for students to take alternative physical science courses such as Earth Science, rather than chemistry or physics.
[6] Further, some research suggests that a student's decision choice to stop studying science as early as possible can be been linked to low interest, or aspirations, towards a career in the sciences (e.g., Stake & Nickens, 2005).

the rest of California) in 1848 at the end of the Mexican-American War (U.S. Department of State, 2015). Los Angeles County, with 88 cities and a population larger than 41 states, had a population of 9,818,605 in 2010 – making it the most populous county in the United States (U.S. Census Bureau, 2010). By way of comparison, Los Angeles County's population is nearly twice that of the next most populous county in the U.S. – Cook County, Illinois, which had a population of 5,194,675 in 2010 (U.S. Census Bureau, 2010). With an area of 4,057 square miles (10,507 km^2*),* Los Angeles County is larger than the combined areas of the U.S. states of Rhode Island and Delaware (U.S. Census Bureau, 2010).

The demographic composition of Los Angeles County has changed steadily over the last fifty years. For example, in 1960, Latinos comprised 9.6% of the total population of Los Angeles County (582,309 of 6,039,834); currently, it is estimated that Latinos make up over 50% of the population of Los Angeles County, and this percentage is expected to grow (U.S. Census Bureau, 2010). The impact of the Latino demographic shift in Los Angeles County is particularly evident in the community of East Los Angeles.

1.3.2 History and demographics of East Los Angeles

In the 1880s a Mexican-American community began to emerge east of central Los Angeles, in part due to real estate covenants that set where Mexicans were able to obtain housing (Garcia-Bedolla, 2005). This geographic and social segregation would precipitate the *barrio* (Spanish for neighbourhood) that would become East Los Angeles (commonly known as East LA); the neighbourhood has evolved into the social and cultural hub of Latino Los Angeles (Garcia-Bedolla, 2005). For the purposes of this study, the mapping of East LA was defined by the boundaries of the Los Angeles Unified School District (LAUSD) East district (see Figure 1.1). The LAUSD East district is comprised of the City of Los Angeles neighbourhoods of Boyle Heights, El Sereno, and Lincoln Heights, as well as unincorporated East Los Angeles. As of 2010, East LA had a population of approximately 300,000 – 97.1 % identifying as Latino (U.S. Census Bureau, 2010).

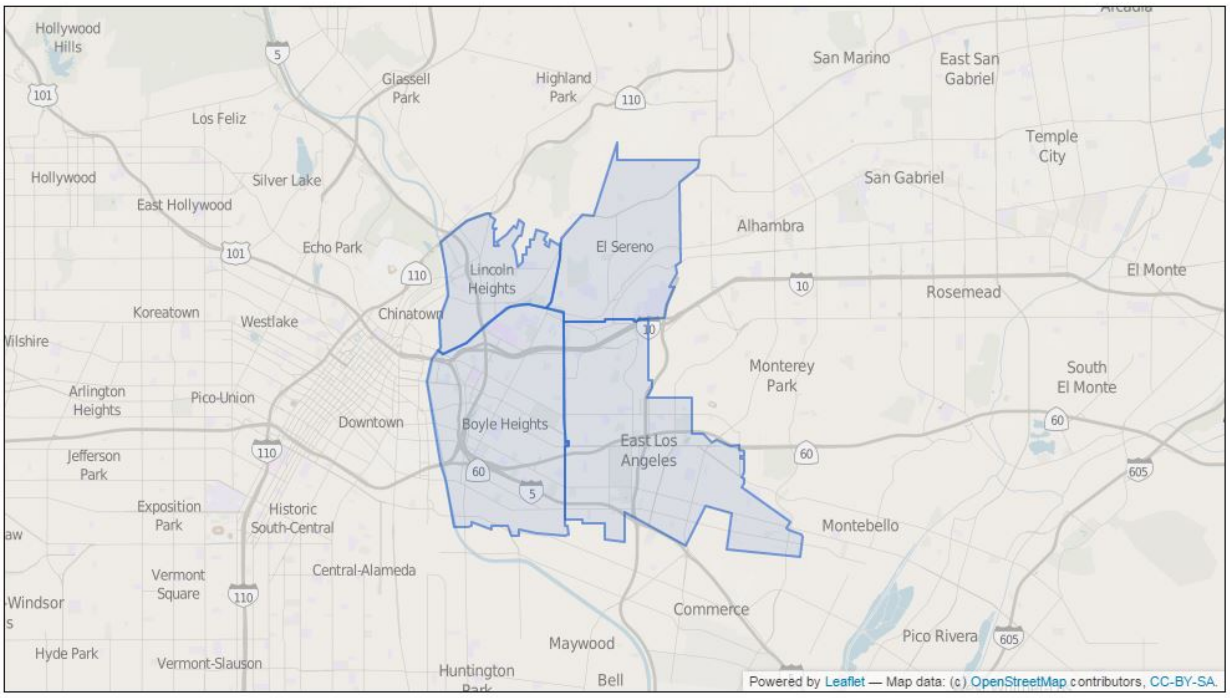

Figure 1.1. Map of East Los Angeles, California (Los Angeles Times, 2015b).

1.3.3 Discrimination and disadvantage in East LA

Over the past 100 years, the community of East Los Angeles has experienced a series of extraordinary discriminatory events. For example, and specifically because of its Latino demographic, East LA was targeted for mass deportations, or "repatriation", by the U.S. government from the 1930s to the 1950s (e.g., Balderrama & Rodríguez, 2006). It has been estimated that one-third of East LA's population was expelled as a result of the government's "repatriation" policy (Balderrama & Rodríguez, 2006). As another example of anti-Latino discrimination, community members were targeted for systematic assault by members of the U.S. military in the 1940s, known today as the "Zoot Suit Riots" (Garcia-Bedolla, 2005). Since the 1960s, East LA has been the epicentre of three major Latino civil rights movements in the U.S.: the 1960s Chicano Blowouts, the 1970s Chicano Moratorium, and the 1990s anti-immigrant Prop 187 protests (e.g., Garcia-Bedolla, 2005; Haney-Lopez, 2001). These events, as well as other factors, have situated the Latinos of East LA "into a position where they [are]

socially, politically, and economically subordinate to the Anglo population" of Los Angeles (Garcia-Bedolla, 2005, p. 46).

Disadvantage accompanies the low societal position of the Latinos of East LA. For example, the persons in poverty percentage (a measure of economic disadvantage) is 26.9% in East LA[7], nearly twice the official U.S. poverty rate of 14.8% (U.S. Census Bureau, 2015). For instance, the East Los Angeles neighbourhood of Lincoln Heights had a rate of 31.7 violent crimes per 10,000 people in 2014 (Los Angeles Times, 2015a). By comparison, in 2014 the adjacent neighbourhood of Montecito Heights had a rate of 16.0 violent crimes per 10,000 people – about half the rate of Lincoln Heights (Los Angeles Times, 2015a).

Despite the layers of disadvantage placed upon the residents of East LA, the community serves "as an important source of contextual capital for Latino residents" of Los Angeles (Garcia-Bedolla, 2005, p. 22). Further, and as popularized in film and music, it is widely viewed as the spiritual heartland of Latinos in California (Garcia-Bedolla, 2005). It is in this area of deprivation – where ethnicity, immigration status, language, poverty, and urban isolation overlap – that the Latino students of East LA develop or do not develop science aspirations. It is in this location that a study into Latino science attitudes and aspirations is most appropriately located.

1.4 Rationale and overview of the study

The causes underpinning the underachievement, underattainment, and underrepresentation of Latinos in the sciences requires investigation. At the highest level, the issues of underattainment and underrepresentation raise questions of when and whether Latinos can integrate into "mainstream" American society. At the local level, the issues are directly related to the discussion of who will be the future participants in the STEM fields in California.

There is a growing body of literature that recognises the importance of the link between early age science aspirations and entry into the STEM pipeline (see Section 2.4). Yet, it appears an

[7] The persons in poverty percentage is 19% overall for the county of Los Angeles (U.S. Census Bureau, 2015).

empirical study exploring the set of unique factors influencing the science aspirations of Latino middle and high school students has not been carried out to date. This research is such a study, with the key questions explored being:

1. What are the science aspirations of 6th grade (age 11 to 12) Latino students in East Los Angeles?

2. What are the science aspirations of 9th grade (age 14 to 15) Latino students in East Los Angeles?

3. Which attitudinal factors predict the strength of science aspirations in the two samples? In particular, what is the role of student engagement in science-related activities outside of school, experiences of school science, family attitudes to science, images of scientists, peer attitudes to science, and science self-concept?

4. What are the associations between science aspirations and gender, generation of immigration, home language use, and socioeconomic status?

5. Are there (cross-sectional) differences in science aspirations between the 6th and 9th grade samples?

By exploring Latino science aspirations, it was thought that this research study would contribute to a deeper understanding of the underachievement and underattainment of Latinos in the STEM fields. This study into the contours and correlates of science aspirations among secondary school Latino students contributes to scholarship in the science education field of education research. This research fills gaps in knowledge pertaining to science aspirations by carrying out a systematic study of the influence of science-related attitudes, background characteristics, and school context on the science aspirations of urban Latino students. Specifically, this study was carried out in middle and high schools within the East Los Angeles area of Los Angeles County, with two samples of students: one middle school (6th grade) and one high school (9th grade).

1.5 Thesis structure

This thesis consists of nine chapters, including this introductory chapter; this chapter details the background, context, and structure of the thesis.

Chapter 2 Literature Review

Chapter 2 provides an overview of what is currently known about Latino students' achievement, attainment, attitudes, and aspirations in the sciences, particularly in the context of U.S. secondary schools. Theoretical perspectives of the study are discussed in relation to school, social reproduction, and science aspirations. Empirical research into science aspirations is reviewed, with emphasis on research during middle school years (ages 11 to 14). It is argued through the literature reviewed that science aspirations are a key influence on future attainment of a degree in a STEM field. The chapter ends with the theoretical framing of attitudes and background characteristics thought to be associated with science aspirations in East Los Angeles.

Chapter 3 Methods

Chapter 3 outlines the research methods of the study. The chapter begins with a brief overview of the theoretical considerations that led to the design of this research. A description of the research setting and sample in East Los Angeles, the study participants in 6th and 9th grade, and the sampling strategy is presented. The ASPIRES survey instrument is evaluated with respect to the current study, noting potential limitations in its application to this research. The decision to include additional student background measures (e.g., generation of immigration, home language use) to the survey instrument is discussed. Possible ethical concerns of the study are considered, along with a review of the information sheets and consent forms used in this study. A full description and the results of the pilot study conducted to determine the suitability of the ASPIRES questionnaires for students in East Los Angeles schools is presented. Lastly, an overview of the design of the data analysis is provided: data coding (for use with SPSS 22), principal components analyses (PCA) carried out to identify constructs of interest, generation of additional measures, multiple regression analyses of predictors of science aspirations, and further inferential analyses. Taken together, the data analysis explores the extent to which students' science aspirations and science-related

attitudes interact with their gender, generation of immigration, home language use, and socioeconomic background – and in this way answer the research questions of this study.

Chapter 4 Generation of variables

This results chapter explicates the creation of measures used in the inferential analyses of the survey data. The chapter begins with a description of the principal components analyses used to identify and extract constructs (components) theorized to be related to science aspirations. The assessment, discussion, and creation of scores for each component is presented. Next, the creation of student background measures is detailed. Lastly, a detailed set of descriptive statistics for the *Aspirations in science* construct is compared and contrasted by gender, generation of immigration, home language use, and socioeconomic status. The above analyses answer the first two research questions: "What are the science aspirations of Latino students in East Los Angeles?".

Chapter 5 Multiple regression - 6th and 9th grade

This results chapter describes the hierarchical multiple regression analyses carried out in order to answer Research Question 3 - "Which attitudinal factors predict the strength of science aspirations in the sample?" and Research Question 4 - "What are the associations between science aspirations and gender, generation of immigration, home language use, and socioeconomic status?". The results of the analyses showed that 6th grade students' experience of school science, family attitudes to science, images of scientists, and participation in science outside of school were the strongest predictors of their science aspirations. On the other hand, the best predictors of 9th grade students' science aspirations were family attitudes to science, self-concept in science, experience of school science, peer attitudes to science, and participation in science outside of school science. Several background measures included in the regression analysis are shown to be mediated through attitudinal components.

Chapter 6 Comparisons of 6th and 9th grade analyses

This results chapter compares and contrasts the results of the 6th and 9th grade analyses in order to answer Research Question 5 "Are there (cross-sectional) differences in science aspirations between the 6th and 9th grade samples?". Three trends emerge through the

comparisons. First, the younger students held more positive science aspirations overall, relative to the older students. Second, measures related to social context appear to be of more importance to the older students' science aspirations, compared to the younger students. Lastly, while school effects were significant for the older students' science aspirations, they were not significant for the younger students.

Chapter 7 Teacher interviews

Chapter 7 presents the member check interviews conducted with ten of the teachers participating in the main study, providing teachers' perspectives on the results of the data analyses. The chapter begins with a section describing the methods of the interviews[8], followed by an overview of the data analysis. The findings of the analysis located seven categories of coded responses that were subsumed by the main theme emerging from the analysis: East Los Angeles subculture.

Chapter 8 Discussion

This chapter relates the principal empirical outcomes of the four data analysis chapters to each other and to the literature review – placing the contribution of this study to the understanding of urban Latino science aspirations into context. The results of this study suggested that influences on science aspirations act and interact in a multiplicity of ways, with post analysis teacher interviews providing valuable perspectives on the results. The results and findings are discussed in relation to sociocultural theories which stress the structuring effect of U.S. society on aspirations. The main original contribution this research makes to knowledge – a rich, detailed, empirical understanding of science aspirations and attitudes of 6th and 9th grade Latinos in East Los Angeles – is discussed. Lastly, it is argued that the outcomes of this study demonstrate that a deep understanding of science aspirations in disadvantaged minority communities can be gained through the application of theories from areas of social research not commonly applied to science education research.

[8] The decision to interview teachers was taken approximately two years after the main survey data was gathered. Thus, it was considered appropriate to place the interview methods, analysis, and findings in a separate chapter.

Chapter 9 Conclusion

The concluding chapter of this thesis evaluates the study's limitations, discusses its implications, and suggests a line of further research. Some key limitations of theory, design, and implementation are detailed, including: the theoretical perspectives used, issues with self-reported data, the cross-sectional nature of the study, the restricted range of some measures, the analysis techniques chosen, and the generalisability of the results. The implications of this study for science education policy and practice are discussed, particularly with respect to Hispanic-serving institutions (HSI) in the greater Los Angeles area. Finally, recommendations for future research are presented, including the possibility of a district wide (LAUSD) longitudinal study into science aspirations.

CHAPTER 2 LITERATURE REVIEW

2.1 Introduction

This chapter presents an overview of current empirical research related to urban Latino students' science participation and aspirations, highlighting key ideas and theories that provide background for this thesis. The first section of this chapter presents the scope, exclusions, and general findings of this literature review. Next, demographics pertinent to Latino participation in science and science education are examined. Then, research aimed at influencing and maintaining participation in science and STEM career paths are reviewed, focusing on science-related achievement and attitudes in middle school. Following, aspirations and associated concepts relevant to science education are explored. Lastly, factors theorized to influence science aspirations are reviewed and evaluated with respect to this study.

2.1.1 Scope and exclusions

This literature review focuses on science aspirations and the science-related attitudes theorized to influence them. In addition to research specific to the sciences, research from the broader STEM fields (Science, Technology, Engineering, and Mathematics) was included in this review; the broader research into STEM participation and attitudes is closely related to science aspirations and attitudes. The literature reviewed in this chapter suggests that post-secondary participation in the sciences can be understood as the outcome of the interactions of prior science-related achievement, aspirations, attainment, and attitudes. Consequently, attention is given to literature on these topics during secondary school years. While it is recognized here that both mathematics and reading achievement and attainment are intrinsically bound-up with science achievement and attainment, these topics were not emphasized in this review due to space limitations. Lastly, while this chapter reviews research from a variety of international contexts, the focus of this review is on research carried out in the U.S. – where this study was located.

2.1.2 General findings

The literature reviewed in this chapter points to gaps in achievement, attainment, and participation in the U.S. at intersections of ethnicity, gender, and socioeconomic position. More specifically, the literature demonstrates that U.S. Latino students have significantly lower achievement and attainment in the sciences relative to Whites, in both middle school and high school. Gaps in science achievement and attainment in secondary school were linked to the underrepresentation of Latinos in the sciences, and the STEM fields generally, post-secondary school and beyond. The literature also suggests that aspirations to attain a first degree in the sciences are significantly linked to science-related attitudes and academic achievement.

2.2 Latino STEM participation in Los Angeles

This section reviews literature relevant to science and STEM participation in the context of this study: East Los Angeles, Los Angeles County, California, U.S. (referred to in this thesis as East LA). First, recent U.S. STEM field participation is placed in context. Then, Latino participation and representation in science and STEM fields are examined.

2.2.1 Demographics of global entry into STEM field participation

In the past fifty years, STEM subfields such as Information Technology, Biotechnology, and Renewable Energy have largely driven the U.S. (and the wider global) economy (e.g., U.S. Congress Joint Economic Committee, 2012). Yet, despite the importance of the STEM fields to the U.S. economy, the U.S. rate of attainment of a first degree[9] in a STEM field – one common indicator of future STEM participation – is quite low relative to many countries. For example, in 2002 the U.S. awarded just 16.7% of its first university degrees in STEM fields, slightly lower than the U.S. 30-year average of 17% (Kuenzi, 2008). By comparison, Japan led the world (among countries that awarded over 200,000 first degrees annually) with 64% of first degrees awarded in STEM; Brazil had the lowest rate (15.5%) and the U.K. rate was 25.8% (Kuenzi, 2008). Providing further context, the average of over 100 other countries in

[9] A first degree in the U.S. is a Bachelor's degree.

2002 was 26.4% (Kuenzi, 2008). Thus, the relatively low attainment of U.S. first degrees in STEM fields in recent years does not suggest future growth in participation in STEM field occupations in the U.S. Deeper insight into future STEM participation in the U.S. is gained by examining the U.S.'s relatively low rate of STEM degree attainment by race and ethnicity.

2.2.2 Latino underrepresentation in education and the STEM fields in the U.S.

To begin, note that participation and attainment in higher education in the U.S. are not representative of its demographics. For example, Table 2.1 displays the percentage of the U.S. population, by ethnicity/race and age, holding a bachelor's degree or higher in the year 2010. As seen in the table, there are considerable differences in attainment by ethnicity among the general population (over 25 years old), with Latino attainment (13%) less than half that of Whites (31%) and less than a third that of Asians (50%). Patterns of attainment are similar for both the general Latino population (13.0%) and recent college-age Latinos (13.5%).

This study is focused on Latino science aspirations. Consequently, it is useful to specifically examine the rates at which first degrees in science-related (STEM) fields are awarded in the U.S. by ethnicity. Utilizing statistics reported by National Science Foundation in 2012 (most recent available), a breakdown of the proportion of first degrees awarded in 2009 by ethnic group in the U.S. is presented in Table 2.2. As shown in the table, the proportion of Whites attaining a degree in the STEM fields (63.3%) was quite close to the proportion of Whites in

Table 2.1. Percent of the U.S. over 25 population and 24-29 population with bachelor's degree or higher in 2010, by ethnicity/race.

Ethnicity/race	General population: Over 25 years old[a]	Recent college graduates 24-29 years old[b]
Asian	50.2	52.5
Black	17.7	19.4
Latino	13.0	13.5
White	30.9	38.6

Notes: Columns do not sum to zero.
[a]Data sourced from U.S. Census Bureau (2012).
[b]Data sourced from the National Center for Education Statistics (2015a).

Table 2.2. Proportion of total bachelor's degrees awarded by ethnicity/race in 2009.

Degree field[a]	Asian (%)	Black (%)	Latino (%)	White (%)
All fields	6.5	9.0	8.5	66.0
STEM	9.6	8.3	8.5	63.3
U.S. Population[b]	4.8	12.6	16.3	72.4

Notes: Rows do not sum to zero.
[a]Data sourced from National Science Foundation (2012b).
[b]Data sourced from U.S. Census Bureau (2010).

the overall U.S. population (about 72.4%). On the other hand, Latinos attained only 8.5% of all STEM bachelor's degrees awarded, while composing 16.3% of the U.S. population.

The disproportionate attainment of first degrees in a STEM field by Latinos in 2009 occurred despite statistics indicating more Latinos (37.2%) than Whites (30.1%) had entered into a STEM major five years earlier (NSF, 2007). Further, there had been growth in the percentage of Latinos entering a STEM field in university during this time span, increasing from 36.4% in 2002 to 40.7% in 2010 (NSF, 2012a). Thus, perhaps it is an issue of persistence in the STEM pipeline, rather than issues relating to entering into the STEM pipeline, that leads to gaps in Latino STEM attainment.

Persistence to attaining a bachelor's degree in a STEM field by Latinos has been relatively low historically (NSF, 2012b), although there are indications of improvement in the rate of persistence in recent years. For example, Table 2.3 displays the percentage of students declaring a STEM major upon entering university in 2009, together with the percentage of declared STEM majors attaining a bachelor's degree in a STEM field in 2015[10], by ethnic group. The table shows similar percentages in 2009 of "entering into a STEM degree program" for Whites (34.0%), Blacks (35.7%), and Latinos (39.7%). As seen in the table, of those Latino students who entered into a STEM degree program in 2009, about one in four

[10] Six years is considered the average time span required to attain a first degree in the U.S. (NSF, 2012b).

Table 2.3. Persistence in entering and attaining a first degree in a STEM field in the U.S. by ethnicity/race: 2009 to 2015.

Ethnicity/race[a]	Total college freshmen in 2009	Entered degree in STEM 2009 (%)	Attained degree in STEM 2015 (%)
Asian	154,599	50.4	38.2
Black	328,444	35.7	16.3
Latino	323,708	39.7	24.5
White	2,231,479	34.0	16.8

Notes: Columns do not sum to zero.
[a]Data sourced from National Science Foundation (2012a).

(24.5%) persisted to attain a first degree in a STEM field six years later; a larger percentage than Whites (16.8%), although lower than Asian (38.2 %). Thus, it is unclear that persistence is a key issue driving Latino underparticipation in the sciences and STEM fields.

The historic and ongoing underparticipation and underattainment in the STEM pipeline by some groups – and by Latinos in particular – has not gone unnoticed. On the contrary, the issues detailed above have prompted a variety of interventions by academic, government, and industry groups.

2.3 Influencing and maintaining participation in the STEM fields

2.3.1 Examples of interventions to influence STEM interest, persistence, and participation

There has been no shortage of efforts in the U.K. and U.S. to stimulate and maintain student interest in STEM careers in recent decades (e.g., Nunes et al., 2017; Valla & Williams, 2012). Examples of interventions seeking to influence STEM interest and persistence during students' secondary-school years (ages 11 to 18) include, for instance, after-school science programs (e.g., Hammrich, Fadigan, Richardson, & Livingston, 2003), early introduction to STEM careers (e.g., Benore-Parsons, Fisher, & Heady, 1995), summer science camps (e.g., Gibson & Chase, 2002), teaching programmes aimed at improving pupils' scientific reasoning or literacy (e.g., Nunes et al., 2017), and university outreach (e.g., Sorge, Newsome, & Haggerty, 2000).

It is unclear, however, whether such interventions are actually effective in achieving their aims (Nunes et al., 2017; Valla & Williams, 2012). For example, in a review of intervention programs in the U.S., Valla and Williams (2012) note:

> While it is encouraging to read anecdotes detailing excitement and positive feedback of participants … if this excitement and feedback masks program ineffectiveness, then in the long run it provides only a false sense of progress. Considering the number of poorly evaluated programs, substantial resources may be unwittingly wasted on ineffective programs. (p. 15)

Indeed, Atkinson and Mayo (2014) argue that implementing programs nationwide, when relatively few high school students (~ 5%) go on to STEM careers, make "solutions prohibitively expensive relative to the benefit" (p. 60). Further, regardless of the type of intervention program, it appears that attitudes towards a career in science have largely set by the start of high school (e.g., Osborne, Simon, & Tytler, 2009; Tytler & Osborne, 2012).

Interestingly, this may not be the case for middle school (ages 11 to 14). For example, Gibson and Chase (2002) found in a study set in three urban schools in Massachusetts, U.S., that interventions can be significant in developing and maintaining positive attitudes towards science. In a longitudinal study into the long-term impact of a two-week summer program in science, a cohort of 79 eighth grade students (ethnicities not specified) who attended the camp, as well as a control group of 35 eighth grade students, were administered a survey on attitudes toward science. Two years later, after the students had moved into high school, the survey was administered again. Their analysis showed that although interest in science had declined for all students in the study, the decline was significantly less for those that had attended the summer program and that their interest in science was significantly higher than that of the control group (Gibson & Chase, 2002).

However, not all students are presented with the option, or even possess the resources, to participate in a two-week science camp. A large body of research has established that most ethnic minority students in the U.S. (e.g., Latinos) do not have the same opportunities as White students to be involved in STEM interventions and activities – inside or outside of school (e.g., Fadigan & Hammrich, 2004; Gilmartin, Li, & Aschbacher, 2006). Further, it is unclear that an intervention designed for students in Western Massachusetts could produce

similar results 3,000 miles away in, for example, East Los Angeles. Thus, the literature reviewed above suggests that stimulating and maintaining science-related interests and attitudes through interventions requires consideration of the conditions of the students participating in the intervention. That is to say, the theoretical underpinnings of an intervention should account for the context of the intervention.

2.3.2 Theoretical perspectives: School and social reproduction

2.3.2.1 The correspondence principle of Bowles and Gintis

It is important to emphasize at this point that different groups (e.g., Black vs. White, male vs. female) have had different experiences within the U.S. education system, a system which some think has historically functioned to reproduce existing inequalities in society. For instance, Bowles and Gintis (1976), in their work addressing the myth of meritocracy, argue that the ultimate role of education in the U.S. is to reproduce an obedient workforce that believes inequality is inevitable – education occurs in the "long shadow of work" (p. 125). In performing this role, schools "create and reinforce patterns of social class, racial and sexual identification among students which allow them to relate 'properly' to their eventual standing in the hierarchy of authority and status in the production process" (Bowles & Gintis, 1976, p. 11).

Bowles and Gintis (1976) highlight the close parallels between schooling and capitalist society through their correspondence principle. For example, the hierarchy of schools corresponds to that of the workplace, with the role of school principal corresponding to that of the CEO, the role of teachers to supervisors, and students to workers. As another example of the correspondence principle, consider the extrinsic reward of school. For many students, the extrinsic reward of school is not knowledge gained in a subject but grades, a concept which "corresponds" directly to work done for wages rather than job satisfaction.

Bowles and Gintis (1976) maintain that indoctrination into accepting inequalities in U.S. society is accomplished through the hidden curriculum of schools, together with the acceptance of the myth of meritocracy. In this case, the hidden curriculum are lessons learnt at school without being explicitly taught. For example, a "good" student is punctual, works hard,

and respects authority – all desirable qualities in a worker. The myth of meritocracy underpins the belief that unequal outcomes in school (and society) are legitimate, while at the same time not recognizing that "schools are constrained to justify and reproduce inequality rather than correct it" (Bowles & Gintis, 1976, p. 102). Consequently, the myth of meritocracy justifies the wealth and privileges of the higher socioeconomic classes by making it appear that they were gained through open and fair competition (e.g., the school system). However, Bowles and Gintis (1976) show that the main factor predicting a person's (high) income later in life is not ability or "merit", but rather their family's (high) socioeconomic class. Thus, the capitalist economic structure in the U.S. results in stratification that drives inequality in educational and career opportunities. While such stratification affects all students in the U. S., it places an additional layer of disadvantage upon racial and ethnic minorities (e.g., Latinos); these groups are positioned lower in the racial hierarchy of the United States – a position accompanied by negative stereotypes and lower expectations throughout all spheres of society (e.g., Bonilla-Silva, 1997; Flores-González et al., 2014).

2.3.2.2 Bourdieu's view of reproduction in education and society

In contrast to the rather deterministic view of education, class, and social reproduction presented by Bowles and Gintis, Bourdieu argued that the source of reproduction of societal inequalities is found in the unconscious interactions between a person's *habitus*, the *capital* they possess, and the *field* within which they are acting (e.g. Bourdieu & Passeron, 1990). A person's *habitus* can be thought of as encompassing "those dispositions…that predispose a person to view reality in certain ways…without necessarily being conscious of them and without having been formally taught or directed in those ways" (English & Bolton, 2010, p. 50). Thus, according to Bourdieu, *habitus* is both a "structured and structuring structure" (Bourdieu, 1984, p. 170). For example, in this study a student's dispositions, or attitudes, towards science can be considered to be structured by the neighbourhood of East Los Angeles, with those same science-related attitudes in turn structuring science aspirations.
Bourdieu replaces socioeconomic class with *field*, a concept of "networks or configurations that impose values in specific social spaces" (English & Bolton, 2010, p. 32). For the purposes of this study science education will be understood to be a *field* with cultural, educational, and socioeconomic elements. Bourdieu theorizes *capital* to be comprised of three distinct forms:

cultural, economic, and social. Those who participate in a *field* utilize their forms of *capital* to gain power and social standing within the *field*. Thus, for example, a student who knows a scientist (social capital), is well versed in academic English (cultural capital), and attends a summer science camp (economic capital) would be considered to bring a great deal of science-related capital to the science classroom.

2.3.2.3 Family habitus and science capital

Archer et al. (2010, 2012) have proposed utilizing *habitus* as a way to understand family influences on children's science aspirations. For this purpose, they extend the concept of *habitus* to include family in order to "to go beyond simplistic, conscious forms of identification with science (e.g., attitudes to/liking of science) to also encompass values and everyday practices" (Archer et al., 2012, p. 886). Archer et al. (2012) applied their Bourdesian conceptual lens to interview data in the U.K. gathered from 78 parents and 92 students (Year 6). Pertinent to the current study, they found that family "social class plays a key role in promoting, facilitating, or hindering children's science aspirations and identifications" (Archer et al., 2012, p. 889), with more advantaged families better able to encourage and make possible a range of science-related activities. In turn, participating in science-related activities – theorized to produce science-related *capital* – advantages children in science education, a key process in social reproduction.

Noting that the value of *capital* is determined by the *field*, Archer, Dawson, DeWitt, Seakins, and Wong (2015) suggest supplementing Bourdieu's theory of social reproduction with the concept of *science capital* for use in science education research. Archer et al. (2015) conceive of *science capital* as consisting of a set of science-related forms of cultural and social capital. They further theorize that within a given set of science-related capital, certain forms produce advantage in the science classroom to a greater extent than other forms. For example, attending a science museum and having a scientist in the family can both be considered forms of science-related capital. However, it is possible that regular contact with a scientist advantages a child in science class to a greater extent than regular visits to a science museum.

Archer et al. (2015) operationalized the concept of *science capital* by analysing data from a survey of secondary schools in England (the survey was designed around their theorization of *science capital*). Their analyses identified key dimensions of *science capital*, including science literacy, science attitudes, transferability of science qualifications, science-related practices, and science-related social capital (see also DeWitt, Archer, & Mau, 2016). Further, Archer et al. (2015) found the distribution of *science capital* to be patterned by class, gender, and ethnicity. Pertinent to the current study, the dependent variable in Archer et al.'s (2015) analyses of *science capital* consisted of a measure of 'anticipated science participation' (together with one 'science identity' item). More specifically, the items comprising the 'anticipated science participation' measure were identical to the questionnaire items used in the current study to measure science aspirations (see Section 3.5).

Note, however, that the idea of science capital has been contested by some. In a critical response to Archer et al.'s (2015) theorization of *science capital*, Jensen and Wright (2015) argue that *science capital* is not meaningfully distinct from Bourdieu's original conception of *cultural capital*. As well, they question the formulation of the empirical measure. For example, they note that "if 'science capital' includes economic capital, then saying that it is unequally distributed according to economic background/capital is tautological" (Jensen & Wright, 2015, p. 1145). Jensen and Wright (2015) conclude that Archer et al. (2015) are pushing "in the wrong direction" (p. 1146) with the concept of *science capital*. Rather, they suggest Bourdieu's existing "conceptual toolkit" is sufficient for understanding how distributions of capital impact science participation (Jensen & Wright, 2015).

Nonetheless, through extended analysis of their data DeWitt et al. (2016) show that their measure of '*science capital*' was a statistically significantly better predictor of student responses to science-related aspirational measures than a more general measure of *cultural capital* – although both measures of capital were closely correlated. Thus, DeWitt et al.'s (2016) results support Archer et al.'s (2015) argument for the use of *science capital* as a conceptual lens, an appropriate analytic tool useful in "understanding the reproduction of inequalities in science participation" (p. 943). Consequently, the use of the term 'science

capital' in this thesis draws upon Archer et al.'s (2015) general theorization of *science capital* as consisting of science-related forms of cultural and social capital.

Although the underlying mechanisms driving social reproduction are debateable, there is agreement between the ideas of Bowles, Gintis and Bourdieu that social reproduction operates to a large extent through education systems. From this perspective, it is conceivable that the ongoing underparticipation of Latinos in the sciences, a form of social reproduction, is linked to the U.S. school system within which they are educated. That is to say, a young person's aspiration (or not) for a future in the sciences is, to some extent, shaped by school – school shaped by wider social, economic, and political considerations. It follows, then, that the phenomena of Latino underrepresentation in the sciences can be better understood by examining young people's science-related aspirations, and influences upon them, in school-related contexts.

2.4 Influences on science-related aspirations

This section of the literature review examines research into science-related aspirations in school settings. First, research related to science aspirations conducted with minority groups in the U.S. is examined. Then, an overview of factors theorized to influence aspirations towards achieving a first degree in the sciences is presented. Next, the role of achievement in shaping science aspirations is explored in the literature. Following, the influence of science-related attitudes on science aspirations is reviewed. Lastly, research identifying gaps in science aspirations and attitudes by gender, ethnicity, and class groups is examined.

2.4.1 Insight into Latino science aspirations from research conducted with minority groups in the U.S.

Historically, the majority of research conducted with minorities in the U.S. has focused on the "black-white" educational attainment gap and addressed precisely those two groups (e.g., Mickelson, 1990), with less systematic research on educational attainment among other minority groups such as Latinos (Tienda, 2009). In recent years, however, there has been an increasing amount of education research focused on historically marginalized groups, research that has highlighted the importance of science-related achievement, attainment, attitudes, and

aspirations. Some of this research has explored topics closely related to this study of urban Latino science aspirations, topics including the attitude-achievement paradox (Mickelson, 1990), identification with science (e.g., Calabrese Barton, 1998; Calabrese Barton, Tan, & Rivet, 2008; Tan & Calabrese Barton, 2008), prototypical science and science identity (e.g., Carlone, 2003, 2004; Carlone & Johnson, 2007), and gaps in science-related achievement and aspirations (e.g., Riegle-Crumb, Moore, & Ramos-Wada, 2011; Riegle-Crumb & Moore, 2014 – reviewed in Sections 2.4.2 to 2.4.5).

2.4.1.1 The attitude-achievement paradox

In a quantitative study located in eight Los Angeles public high schools, Mickelson (1990) investigated the paradox of positive attitudes toward education found alongside academic underachievement among Black adolescents. Mickelson (1990) hypothesized that this "attitude-achievement paradox" was the result of the often contradictory "dual nature of people's beliefs" (p. 58) about the value of education in the U.S. In order to test her hypothesis, Mickelson (1990) explored the effect "abstract attitudes" (which reflect the hegemonic ideology of the dominant White majority regarding the value of education) and "concrete attitudes" (shaped by expectations of real-life benefits accrued from education) had on academic achievement. Mickelson (1990) found the difference between the "abstract attitudes" and "concrete attitudes" of Black students, on average, to be significantly greater than that of the White students in her study. Specifically, Black students tended to report higher "abstract attitudes" and lower "concrete attitudes" than White students. Further, she found that while the "concrete attitudes" measure was a significant predictor of Black students' academic achievement, "abstract attitudes" was not. In other words, Mickelson's results suggest that a critical factor in a student's academic achievement is a "student's perceptions of what her or his efforts in school will ultimately bring from larger society" (Mickelson, 1990, p. 59), more so than a student's acceptance of society's presentation of education as an important path in social mobility.

2.4.1.2 Identification with science

In exploring the challenges and inequities faced by youth from historically marginalized communities, Calabrese Barton has conducted a great deal of qualitative research in the

Northeast of the U.S., particularly with urban middle school girls (e.g., Calabrese Barton, 1998; Calabrese Barton, Tan, & Rivet, 2008). Addressing fundamental equity concerns in science education, Calabrese Barton et al. argue that students from disadvantaged backgrounds (e.g., urban Latina middle school girls) do not identify easily with the dominant culture of science learning found in both formal (Calabrese Barton et al., 2008) and informal settings (Calabrese Barton & Tan, 2018). Calabrese Barton et al. suggest that identification with science often requires youth belonging to groups historically marginalized from science to "abandon their cultures" (Calabrese Barton & Yang, 2000, p. 887), in turn frustrating youth from expressing "who they are and want to be in ways that meaningfully blend their social worlds with the world of science" (Calabrese Barton & Tan 2010, p. 226). Calabrese Barton et al. suggest that in order to sustain engagement (and identification) with science among historically marginalized groups such as, for instance, Latina middle-school students, learning environments supportive of their "identity work" are required (e.g., Calabrese Barton et al., 2012; Calabrese Barton & Tan, 2018) – learning environments which acknowledge and value their personal experiences.

2.4.1.3 Science identity and prototypical science education

Carlone and Johnson (2007) have proposed a model of "science identity" in order to understand the experiences of women science students of colour at a large public university in the Eastern U.S. Their model of science identity is comprised of three overlapping dimensions: competence, performance, and recognition. Of interest to the current study is the dimension of "recognition", which Carlone and Johnson (2007) suggest depends on both self-identification as a "science person" and recognition from others. Specifically, Carlone and Johnson (2007) found that some women of color developed "disrupted" science identities along the dimension of "recognition", having had "experiences where they felt overlooked, neglected, or discriminated against by meaningful others within science" (p. 1202). Carlone and Johnson (2007) point out that those experiences were a direct result of the study participant's ethnicity, gender, or race – experiences that were later recalled with

"bitterness"[11] (p. 1202). Carlone (2004) suggests that in the school setting, a lack of recognition is one outcome of the "powerful sociohistorical legacy of school science" which has produced a "prototypical science education" system in US schools that acts to alienate those, such as Latinas, who have not traditionally been successful in science (2004, p. 394).

2.4.2 Factors theorized to influence science aspirations

A large body of recent research, using a variety of methods, has sought to identify factors that influence a student to enter into the "pipeline" to achieve a first degree in the sciences (e.g., Adamuti & Andres, 2008; Aschbacher, Ing, & Tsai, 2014; Crisp, Nora & Taggart, 2009; Dabney et al., 2012; DeWitt et al., 2011; Gilmartin, Li, & Aschbacher, 2006; Sjøberg & Schreiner, 2005; Schoon, 2001; Wang & Staver, 2001; Wang, 2013). These studies have been carried out at different intersections of age, ethnicity, gender, and socioeconomic class in the U.S., U.K., and elsewhere. As well, each study holds a unique perspective on the relative importance of theoretical considerations such as academic experiences (e.g., Aschbacher et al., 2014), cognitive processes (e.g., Beghetto, 2007), sociocultural context (e.g., DeWitt et al., 2011), and socioeconomic condition (e.g., Gilmartin et al., 2006).

In general, however, there is widespread consensus among science education researchers that prior academic achievement is an important influence on a student's choice to study a STEM field in college (e.g., Osborne, Simon, & Tytler, 2009; Riegle-Crumb & Moore, 2011; Schoon, 2001; Tai, Liu, Maltese, & Fan, 2006; Wang, 2013). In the U.S., for instance, Riegle-Crumb et al. (2011) found that low academic achievement in high school decreases the prospects of a young person attaining a first degree in the sciences, pointing out that low "achievement is a key obstacle to equity later in STEM pathways" (p. 462). Consequently, and in order to better understand how the underrepresentation of Latinos in the sciences is linked to previously held science aspirations, it is useful to examine research into science-related achievement in schools.

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[11] While the women in Carlone & Johnson's (2007) study continued with science at university level, there are likely many other students who have had similar experiences, experiences which led them not to continue in science.

2.4.3 The role of academic achievement in shaping science aspirations

2.4.3.1 High school

To clarify, the use of the term "academic achievement" in this thesis includes academic preparedness for attaining a first degree in a STEM field such as, for example, science courses taken. Previous research has established that academic achievement in both science and mathematics is significant in predicting aspirations to a future science career (e.g., Crisp et al., 2009; Riegle-Crumb et al., 2011; Schoon, 2001; Tai et al., 2006; Wang, 2013). For example, Schoon (2001) investigated the predictive validity of STEM aspirations in a 17-year longitudinal study carried out in the U.K. Schoon (2001) found that STEM aspirations at age 16 were significantly related to test scores in mathematics. Pertinent to the current study, Schoon (2001) showed that science aspirations at age 16 significantly predicted a science career at age 33. Interestingly, the study also found that STEM aspirations and STEM outcomes were both significantly related to gender and social background (Schoon, 2001). Schoon (2001) highlighted the complexity of the interplay between aspirations, achievement, background characteristics, and future occupational attainment by noting that "for the understanding of occupational development across the lifespan both individual and contextual factors have to be considered" (p. 124).

With respect to gender, however, there is evidence that there is currently no aggregate difference, or "gap", in science and math achievement between genders in the U.S. in high school years (Hyde, Lindberg, Linn, Ellis, &Williams, 2008). On the other hand, gaps in academic achievement in both science and math by ethnicity have been found in U.S. high schools for the past fifty years (e.g., Hemphill & Vanneman, 2011; Quinn & Cooc, 2015). For instance, Quinn and Cooc (2015) show that, historically, Latino students score significantly lower on standardized national science exams compared to White students. This outcome is of interest to this study because, among other things, academic achievement in science has been shown to be linked to students' school science experiences (e.g., Smith & Ochoa-Angrino, 2012). Specifically, Smith and Ochoa-Angrino (2012) found that when a student has had a negative academic experience in a gateway science course (courses such as physics that are either developmental or prerequisite for entry to later science courses) further participation in STEM courses is less likely.

Ethnic gaps in academic science achievement and attainment can be observed through measures other than standardized testing. For example, Table 2.4 displays the percentage of U.S. high school graduates who completed specific science courses in high school for the year 2005, by ethnicity/race. As shown in the table, Latinos have the lowest completion percentage of any ethnic group across all science courses and combinations of science courses. For example, there was more than a 10% difference between Latinos and Whites who completed biology, chemistry, and physics, and nearly a 25% difference between Latinos and Asians on the same measure. While recognising science class completion is just one possible measure of science attainment, Table 2.4 usefully illustrates U.S. gaps in the science or STEM pipeline at the high school level by ethnicity.[12] As well, the statistics presented in the table are of interest to this study given that some research suggests that lower achievement and attainment in high school science courses tend to reduce aspirations to enter into a STEM major, post-secondary school (e.g., George, 2006; Smith & Ochoa-Angrino, 2012). Intriguingly, that does not seem to be the case in middle school years.

Table 2.4. Percentage of high school graduates who completed selected science courses in high school by ethnicity/race in 2005.

Ethnicity/race[a]	Biology (%)	Chemistry (%)	Physics (%)	Biology & Chemistry (%)	Bio, Chem, & Physics (%)
Asian	92.1	79.4	49.9	75.5	42.8
Black	93.6	63.6	25.8	62.0	21.3
Latino	89.1	59.2	23.3	57.2	18.9
White	92.6	67.1	34.6	65.3	29.0

Note: [a]Data sourced from Aud, Fox, & KewalRamani (2010).

[12] Note that the gap in science class completion exists despite some research showing that Latino (and Black) students, on average, assess their own science ability to be *higher* relative to White students within their own high school (Riegle-Crumb et al., 2011).

2.4.3.2 Middle school

Gaps in achievement by ethnicity have been observed in middle school (e.g., Bromberg & Theokas, 2014; Hemphill & Vanneman, 2011; NCES, 2015b; Tai et al., 2006), yet they do not appear to be associated with science aspirations in the same way observed during high school years. For example, an analysis of National Education Longitudinal Study (1988) data was carried out by Tai et al. (2006) in order to examine the outcomes of the career aspirations of U.S. middle school students. The study followed students from eighth grade (age 13) until the attainment of a bachelor's degree (a post-secondary four-year degree). Not surprisingly, Tai et al. (2006) found that students who aspired to a STEM related degree in middle school had a much higher rate of attaining a bachelor's degree in a STEM field than those who did not aspire to a STEM related degree. Rather, what is of interest to the current study is their finding relating math ability in eighth grade (noted previously as a predictor of entry into a STEM field), STEM interest, and attainment of a STEM related degree. Specifically, they found that students with low mathematics achievement scores and high STEM interest in middle school had a *higher* rate of STEM degree attainment than students with high mathematics achievement score and low STEM interest (Tai et al., 2006). That is to say, the science aspirations of these students were apparently not impacted by their "low" science-related achievement. Taken together, the research reviewed above suggests that it is more than just academic achievement and background characteristics that influence aspirations towards a science-related career.

2.4.4 The role of attitudes and attitude gaps in shaping science aspirations

"Attitude towards science" has been described as the feelings, beliefs, and values held about the endeavour of science, school science, the impact of science and technology on society, or scientists (Osborne, Simon, & Collins, 2003). A substantial number of studies, in both the U.K. and U.S., have long identified positive attitudes towards science and mathematics as a strong predictor of entry into a STEM field in the future (see the review papers by Osborne, Simon, & Tytler, 2009; Schibeci, 1984; and Tytler & Osborne, 2012). As well, previous research (e.g., Osborne, Simon, & Tytler, 2009; Tytler & Osborne, 2012) has found differences, or "gaps" in science attitudes with respect to a variety of student background characteristics (e.g., ethnicity, gender, socioeconomic status).

2.4.4.1 High school years

Studies in both the U.K. and U.S. have found that high school science and mathematics attitudes are generally as favourable across most minority ethnic groups as they are among White students (e.g., Aschbacher, Li, & Roth, 2010; Catsambis, 1995; Gibson & Chase, 2002; Gilmartin et al., 2006). However, a number of studies have found gender gaps in attitudes towards science and mathematics at the high school level, with boys generally having more positive science-related attitudes compared to girls (e.g., Correll, 2001; Riegle-Crumb et al., 2011). In the past some have argued that this is due perhaps to intrinsic differences between male and female "math ability" (Peng & Jaffe, 1979). While this notion might persist today, it is not substantiated: any gender gaps in U.S. standardized mathematics test scores that once existed have largely disappeared (Hyde et al., 2008). Thus, while the literature suggests that gender gaps in *attitudes* towards science and mathematics exist and even widen in high school years (e.g., George, 2006; Maltese & Tai, 2010), this occurs despite similar *achievement* in science and mathematics. For example, in the U.S., Correll (2001) showed that even when scores on tests of math ability were equivalent for high school boys and girls, on average boys still possessed greater self-concept[13] in mathematics than girls. Correll (2001) suggests that "boys do not pursue mathematical activities at a higher rate than girls do because they are better at mathematics. They do so, at least partially, because they think they are better" (Correll, 2001, p. 1724). As a result, Correll (2001) argues, gendered self-assessment of mathematical competence "leads to gender differences in decisions to persist on a path toward a career in science, math, or engineering" (p. 1691).

2.4.4.2 Middle school years

As with the high school age group, previous studies have generally found positive attitudes towards science in middle school age students across ethnic groups (e.g., Aschbacher et al., 2014; DeWitt et al., 2011; Riegle-Crumb et al., 2011; Wang, 2013). As with high school age students, gender gaps in science-related attitudes have been observed in middle school years,

[13] *Self-concept* is broadly defined in this study as a student's self-assessment of how "good" they are in an academic field. Thus, mathematical self-concept refers to a student's perception or belief in her or his ability to do well in mathematics, as well as confidence in learning mathematics.

with boys generally exhibiting more positive attitudes towards science and mathematics than girls (e.g., Riegle-Crumb et al., 2011). For instance, in order to investigate reasons driving the gender gap in middle school science attitudes, Riegle-Crumb et al. (2011) analysed U.S. data from the 2003 TIMSS study of 4th (nine years old) and 8th grade (thirteen years old) students. They found that "it appears that enjoyment of science is perhaps an important driver behind gender differences… at younger ages, at least in the case of White and Hispanic girls" (Riegle-Crumb et al., 2011, p. 472). The findings of Riegle-Crumb et al. (2011), for example, suggest that intersections of ethnicity, gender and age must be considered in research involving science-related attitudes. That is to say, the literature reviewed to this point suggests that factors influencing the science aspirations of a Latina high school student might not necessarily match those of a Latino middle school student.

2.4.5 The role of middle school in shaping aspirations to a science career.

A considerable amount of research details the impact of middle school years on the trajectory of a young person's science-related attitudes (e.g., Barmby, Kind, & Jones, 2008; Catsambis, 1995; Dabney et al., 2012; Ing & Nylund-Gibson, 2012; Riegle-Crumb et al., 2011). Importantly, many studies call attention to the decline in science-related attitudes spanning middle school years (e.g., George, 2000, 2006; Potvin & Hasni, 2014). For example, using data from the Longitudinal Study of American Youth (LSAY), George (2006) found that student attitudes towards science declined significantly over middle and high school years. George (2006) highlighted the importance of science attitudes (and their decline), noting that the "development of positive attitudes toward science can motivate student interest in science education and science-related careers" (p. 571).

Further, a large and growing body of research suggests that the decline in science-related attitudes can commence as early as age 11 – the age at which U.S. students enter middle school (e.g., Eamon, 2005; Potvin & Hasni, 2014; Osborne & Collins, 2001; Sorge, 2007; Tytler & Osborne, 2012). In Canada, for example, a 7-year longitudinal study by Potvin and Hasni (2014) tracked interest in school science through middle school and high school. Potvin and Hasni (2014) reported a steady decline in "in-school" science interest from the 5th grade (10-11 years old) to 11th grade, suggesting that "it might be school itself that is not capable of

holding on to the strong interest sometimes found at the elementary level" in science (p. 795). In the U.S., Sorge (2007) measured science attitudes in elementary school and middle school, following students from ages 9 through 14. Sorge (2007) found a continuous decline in science attitudes over the years, pointing out, however, that the decline was not linear. Specifically, Sorge (2007) notes: "Unmistakably a precipitous drop in science attitudes takes place between elementary school and middle school" (p. 35). Taken together, the research above suggests that it is middle school years, perhaps more so than high school years, that influence and shape interest in a career in science.

At this point it is worth highlighting the central role that schools – particularly middle schools – play in youth development within Latino immigrant and working-class communities (e.g., Moller et al., 2015; Rogers, Saunders, Terriquez, & Velez, 2008). For example, Moller et al. (2015) note that the lack of established science "support networks" within Latino communities increases the impact middle school experiences have upon Latino science attitudes. Moller et al. (2015) point out that Latino middle students "are unique because they reflect on fewer sources of STEM inspiration (such as family friends), suggesting that teachers and teaching environments may play a more vital role... These teachers can inspire Latino/a students and help them enjoy STEM classes" (p. 20). In other words, middle school could possibly have a larger role in shaping the science aspirations of Latino students compared to other ethnic groups in the U.S.

Thus, in light of the literature reviewed to this point, it is reasonable to think that the strongest influences on the science aspirations of Latinos in the middle school years (and high school years) are quite possibly distinct from other student groups in the U.S. An overview of factors theorized in the literature to influence science aspirations in middle school and high school, other than the background characteristics previously considered (i.e., gender and ethnicity), are reviewed next.

2.5 Investigating science aspirations

2.5.1 Defining and organising science aspirations and attitudes

Science aspirations in this thesis refer to the level of interest in entering onto an educational path that results in the outcome of a first degree in a science field. In order to better understand the ways in which science aspirations and attitudes are theorized to be connected to science-related outcomes, it is useful to examine Koballa's (1988) framework linking science attitudes and related concepts to an observable science-related behaviour. Shrigley, Koballa, and Simpson (1988) define an *attitude* as "a learned predisposition to respond consistently favourably or unfavourably toward an attitude object" (p. 666). Figure 2.1 displays this study's adaptation of Koballa's (1988) model of the relations among affective variables leading to science-related behaviours.

As shown in Figure 2.1, a network of affective variables contributes to a specific outcome *behaviour* in science. In this case, "Entering into a science degree programme" is considered to be a science-related *behaviour*, which is linked to an *aspiration* with some aspirational probability (High - 70%) towards enacting that *behaviour*. In turn, *aspirations*[14] in science are theorized to be influenced by a number of science-related *attitudes*. Science *attitudes* are thought of as favorable or unfavorable evaluations of an object[15] such as, for example, one's own self-assessment of one's ability to do science, or "self-concept in science".

Science *attitudes* are considered distinct from a students' science *beliefs*, where "*beliefs* represent the information he has about the object. Specifically, a *belief* links an object to some attribute" (Koballa, 1988, p. 118). In this example, a student's belief that they get good grades in science links the object, "science grades", to the attribute, "good". Koballa (1988) proposes that *attitudes* are dependent on the strength of *beliefs*, noting that "beliefs link objects to attributes at some level of probably between 0 and 100 percent" (p. 118). In this case, a

[14] Koballa (1988) uses the term *intentions* rather than *aspirations*.
[15] Koballa (1988) defines the attitude object as "a person, situation, group, policy, issue, or an abstract idea" (p. 117).

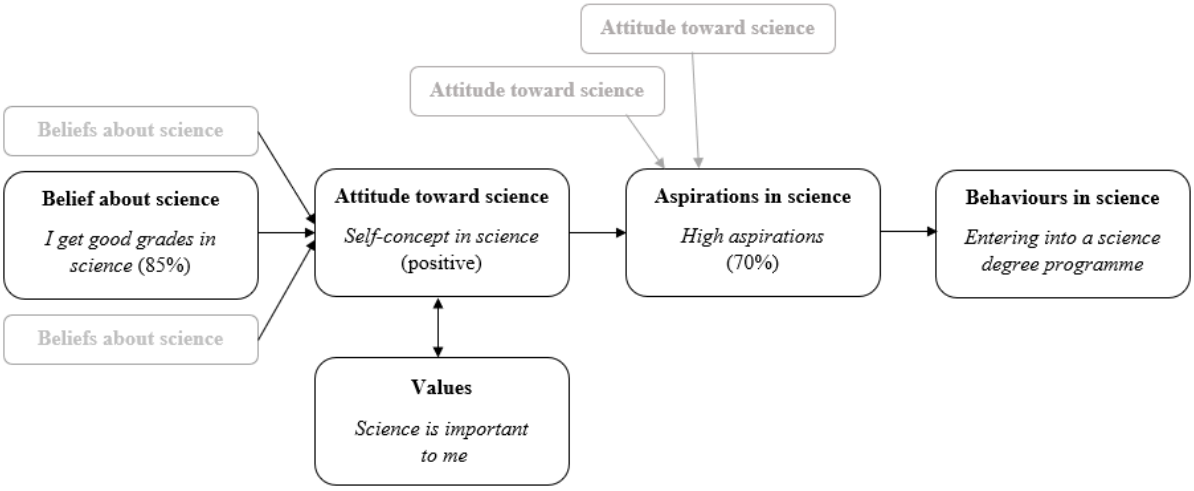

Figure 2.1. Adaptation of Koballa's (1988) model of the relations among affective variables leading to aspirations in science.

student's *belief* "I get good grades in science" with a strength of 85% would strongly influence a positive "self-concept in science" *attitude*.

Attitudes are moderated by a students' background sociocultural *values*. That is to say, the strength of an *attitude* is considered to be impacted by its relation to a person's *values*. In this case, the strength of a student's "self-concept in science" depends in part on how strongly a student values science generally. For example, a student whose mother is a chemist likely values science, a value which in turn would favorably influence their science-related attitudes. By comparison, a student who has no contact with science is unlikely to consider it an important part of their life – or put a great value on science. In general, while people have thousands of *attitudes*, they have only a "few dozen" *values* (Koballa, 1988, p. 120).

Lastly, it is important to stress that the outcome of the interplay of variables shown in the figure results in an observable *behaviour*: entering into a science degree programme. Behavioural outcomes are, after all, the point in studying science aspirations and its influences. As Koballa points out "the science-related behaviors of students and teachers are [the] ultimate interest and concern" of science educators (Koballa, 1988, p. 120).

2.5.2 Attitudes theorized to be associated with science aspirations

Numerous studies, in a variety of contexts, have been carried out seeking to identity attitudes related to science aspirations (see the review papers by Osborne et al., 2003, 2009; Schibeci, 1984; Tytler & Osborne, 2012). This literature review does not attempt to examine all possible factors theorized to be related to science aspirations, but rather focuses on attitudinal factors thought to be closely aligned with the ideas of reproduction of societal inequities through the U.S. education system. Those attitudinal factors include (1) experiences of school science, (2) family influences, (3) outside of school science participation, (4) peer influences, (5) self-concept in science, and (6) student perceptions of scientists.

2.5.2.1 Experience of school science

A great deal of previous research in the U.S. and the U.K. has found students' school experiences to be associated with school outcomes (e.g., Loukas, Suzuki, & Horton, 2006; Lyons, 2006; Woolley & Bowen, 2007) and often more so for non-White ethnic groups such as Latinos (Woolley, Kol, & Bowen, 2009). For instance, Loukas, Suzuki, and Horton (2006) found, in a U.S. study of 10- to 14-year-olds including Latinos, that school "connectedness" was predictive of positive behaviour at school. In turn, positive behaviour at school was associated with better academic performance (Loukas et al., 2006).

Other studies focusing specifically on students' experiences of school science have demonstrated the important influence school science has on shaping future dispositions and attitudes towards science (e.g., Aschbacher et al., 2010, 2014; Barmby et al., 2008; Cleaves, 2005; George, 2006; Gilmartin et al., 2006; Lyons, 2006; Potvin & Hasni, 2014; Sjøberg & Schreiner, 2005), generally finding that negative experiences act to lower science aspirations. For example, Potvin and Hasni (2014), in discussing the decline in school science interest across middle and high school years in Canada, suggest that "something is wrong with what happens in school" (Potvin & Hasni, 2014, p. 797). In the U.K., for example, a longitudinal study by Bennett & Hogarth (2009) concluded that students' perception of the difficulty of certain school science subjects leads to a decreased desire to study the subjects and that "students believe there are greater rewards… for effort put into subjects other than the physical sciences" (p. 1995).

Of particular interest to this study, Aschbacher et al. (2014) found the link between school science experiences and (physical) science aspirations to be particularly important in low socioeconomic status neighbourhoods similar to East Los Angeles. In their study of school science and attitudes set in Southern California middle schools, they found "many students, particularly those in resource-lean homes, have few opportunities at home or after school to compensate for or enrich what happens in school science, so they are particularly vulnerable to poor school science experiences" (Aschbacher et al., 2014, p. 741). Also in the U.S., Gilmartin et al. (2006) found in a California study of 10th grade students that school science experiences significantly influenced science-related career aspirations. Interestingly, they point out that school science experiences were different for different combinations of ethnicity, race, and gender – suggesting that this topic requires further research (Gilmartin et al., 2006).

2.5.2.2 Family influences

A large body of research has demonstrated the important role family plays in shaping students' future career choices (e.g., Behnke et al., 2004; Huang, Taddese, & Walter, 2000), relation with science (e.g., Tenenbaum & Leaper, 2003), and science aspirations (e.g., Adamuti-Trache & Andres, 2008; Aschbacher et al., 2010, 2014; Dabney et al., 2012; Gilmartin et al., 2006). For example, in a study based in Canada, Adamuti-Trache and Andres (2008) examined the influence parents have in disposing their children towards STEM fields of study by transmitting cultural values and practices. Their longitudinal study showed that students with university-educated parents made early decisions about their career path and tended to select science-related disciplines to study in high school. On the other hand, students with less educated parents tended to not take science courses, making it less likely they would later choose to enter into the science pipeline (Adamuti-Trache & Andres, 2008). Drawing upon Bourdieu's ideas to understand their findings, Adamuti-Trache and Andres (2008) suggest that "parents transmit capital in the form of dispositions, habits, and attitudes to their children, resulting in the reproduction of the dominant culture through which background inequalities are converted into differential academic attainment and eventually social status" (p. 1561).

In the U.S., Gilmartin et al. (2006) examined the effects family related variables had on interest in a STEM career in a sample of 10th grade students (ages 15 to 16) in Southern California and found family science orientation was strongly related to STEM career interest. They highlight "the powerful role of family context when exploring early stages of the science and engineering pipeline specifically and students' career aspirations generally'' (Gilmartin et al., 2006, p. 196). Pertinent to the current study is Gilmartin et al.'s (2006) finding that interest in science was patterned by race and ethnicity. Specifically, they note that the importance of family science orientation was greater for Latinos than for the White and Black students in their study. They point out that "this calls attention to the need for recognition of family influence among Latino students in particular" (Gilmartin et al., 2006, p. 28).

Family influences have also been associated with gaps in STEM participation by gender (Tenenbaum & Leaper, 2003), ethnicity (Huang et al., 2000), and socioeconomic conditions (Aschbacher et al., 2010). For example, Tenenbaum and Leaper (2003) found in a study set in California middle schools that "in general, parents held gender-stereotyped expectations regarding their children's science interest and ability" (p. 42), with science thought to be more difficult for girls than boys. Also in the U.S., Huang et al. (2000) analyzed data from the National Education Longitudinal Study of 1988 and found that family support was a direct predictor of the entry into and persistence of women and minorities in STEM fields during college years. Interestingly, one key finding of Huang et al.'s (2000) study was that students who had taken advanced science courses and had parents with relatively higher levels of educational attainment had a greater likelihood of majoring in a STEM field in postsecondary education; a finding which aligns with the research of Adamuti-Trache and Andres (2008) reviewed above. As another example, Aschbacher et al. (2010), in their study based in Southern California middle schools, found different patterns of family support and extracurricular science opportunities by socioeconomic status. They note that the "high achievers" in science in their study tended to come from families that "facilitated extracurricular experiences by seeking opportunities, encouraging participation, paying expenses, and providing transportation" (Aschbacher et al., 2010, p. 576).

2.5.2.3 Outside of school science participation

Previous research has linked participation in science-related hobbies and activities to interest in a science related career (e.g., Aschbacher et al., 2010; Dabney et al., 2012; Barmby et al., 2008; Bennett & Hogarth, 2009; Maltese & Tai, 2010). For example, Barmby et al.'s (2008) longitudinal study in the U.K. examined changes in science aspirations[16] and other science-related attitudes in the U.K. from Y7 to Y9 (ages 11 to 14). They found that the best predictor of science aspirations across all year groups was participation in science outside of school (Barmby et al., 2008).

In the U.S., for instance, Dabney et al. (2012) found that university students who had engaged in outside of school time science activities (OST) – reading science fiction, being in a science club, and doing science activities as children – were more likely to have an interest in a STEM career than those who did not participate in OST. Germane to the current study is their finding associating OST with socioeconomic status; they point out that it "implies that students from a higher socioeconomic background are more likely to participate in OST clubs/ competitions" (Dabney et al., 2012, p. 74). In their California study, Gilmartin et al. (2006) found that high school students who participated in science-related hobbies also "tended to be those students who expressed interest in a Physical Science/Engineering career" (p. 22). Also in California, Aschbacher et al. (2014) highlight that interest and participation in science activities outside of school are important to science aspirations as they act to enrich – and in some cases compensate – for school science experiences.

2.5.2.4 Peer attitudes to science

Other research has shown science-related attitudes to be influenced by peers during school-age years (e.g., Breakwell & Beardsell, 1992; George, 2006; Robnett & Leaper, 2012; Stake & Nickens, 2005; Talton & Simpson,1985; Wang & Staver, 2001). For example, Talton and Simpson (1985), in a longitudinal study in the U.S., examined correlations between friends' attitudes toward science and individual attitudes toward science during grades six through ten;

[16] Barmby et al. (2008) used the term "future participation in science" rather than "science aspirations" for their attitudinal construct.

they found the relation between peer influence and science attitudes to be significant. Talton and Simpson (1985) point out that the relation grew stronger as the students grew older, noting that "individual attitudes toward science become increasingly more like those of the peer group as students progress through middle and junior high school, and that this correlation may reach a peak in the ninth grade" (p. 23). Also in the U.S., Wang and Staver (2001) examined relations between factors pertaining to science education and career aspirations using data from Longitudinal Study of American Youth (LSAY). They found peer influences were positively linked to science-related career aspirations, noting, however, that the "indicator does not always represent a positive influence on student learning and career orientations" (Wang & Staver, 2001, p. 318).

2.5.2.5 Self-concept in science

Much research, and in a variety of contexts, has found young people's beliefs about their own efficacy to be predictive of their aspirations (e.g., Aschbacher et al., 2010, 2014; Barmby et al., 2008; Bandura, Barbaranelli, Caprara & Pastorelli, 2001; Cleaves, 2005; Gilmartin et al., 2006; Riegle-Crumb et al., 2011; Schoon, 2001). For example, Schoon's (2001) longitudinal study in the U.K. investigating the predictive validity of adolescent job aspirations found that that academic self-concepts in teenage age years significantly predicted STEM career attainment later in adulthood. In the U.S., for instance, Aschbacher et al. (2014) found in their Southern California research that science self-perception was significantly related to science career interest in middle school. Also, in the Southern California context Gilmartin et al. (2006) found a positive science self-concept to be, by far, the strongest predictor of career interest in the physical sciences and engineering.

It is worth pointing out here that previous research has shown that science self-concept varies by student groupings such as age, ethnicity, and gender (Beghetto, 2007; Riegle-Crumb et al., 2011). For example, in the U.S., Beghetto (2007) examined middle and secondary students' perceived science competence, noting "males, on average, were found to have more favourable perceptions of their science competence than did females. And Anglo students held, on average, more favourable perceptions than Hispanic students" (p. 807).

2.5.2.6 Student perceptions of scientists

Other research has identified students' perceptions of scientists (e.g., Baker & Leary, 1995; Bennett & Hogarth, 2009; Cleaves, 2005; Miller, Slawinski Blessing, & Schwartz, 2006; Wong, 2015) as being linked to interest in (or not) a science related career. These studies tend to align in finding that middle and high school students generally have positive images of scientists, but that the positive images do not necessarily translate into higher science aspirations. On the other hand, a negative image of scientists acted to negatively impact science aspirations. For example, Bennett & Hogarth (2009) found in their U.K. study that students (ages 11 to 14 years) who indicated that they did not desire a job in the sciences reported a "view of scientists being seen as 'uncaring'" (p. 1995), especially female students. Similarly, Miller et al. (2006) found that the U.S. high school girls in their study perceived the lifestyle of a scientist to be unattractive, preferring a more "people-oriented" career. Pertinent to the current study, Wong (2014) explored the science aspirations of U.K. minority ethnic students (ages 11 to 14 years), finding that these students considered their own ethnicity to be "inconsistent to the typical scientist" (p. 996) – that is to say, white men. Consequently, a career in science was not a popular aspiration among the study's participants.

The literature reviewed to this point illustrates the range of influences theorized to impact science aspirations. However, it is difficult to draw conclusions about how these influences act (if they do) to shape science aspirations in East Los Angeles. As Barmby et al. (2008) point out:

> Attitude research results are not only difficult to transfer from one society to another, but also from one time period to another. Students' attitudes must be regarded as a characteristic of the context in which it [the research] has been conducted. (p. 1080)

Thus, although the factors discussed in this section have been linked to the science aspirations of school-age youth, none of the studies reviewed to this point have examined them together in the U.S. While such a study does not appear to have been conducted in the U.S. to date, a study with such an aim has been carried out in the U.K. and is reviewed next.

2.5.3 The ASPIRES project

The ASPIRES project was a five-year study conducted in the U.K. by a group from King's College London (Archer, Osborne, DeWitt, Dillon, Wong, & Willis, 2013). The project explored science aspirations and engagement among 10- to 14-year-olds. The study combined quantitative online surveys of a student cohort and repeat interviews with a selected sub-sample of students and their parents. Survey and interview data were collected at three time points: the end of primary school (age 10/11, Year 6), the second year of secondary school (age 12/13, Year 8) and the third year of secondary school (age 13/14, Year 9). In total, over 19,000 surveys were completed: 9,319 by Year 6 students, 5,634 by Year 8 students and 4,600 by Year 9 students. A sample of 83 students and 65 of their parents were also longitudinally tracked via interviews across this age range (10-14). The project developed and utilized a survey questionnaire in order to collect attitudinal and demographic data (see DeWitt et al., 2011). The majority of questions used a Likert-type scale to elicit attitudinal responses. Their analysis showed science attitudes and aspirations varied by gender, ethnic, and socioeconomic background (DeWitt et al., 2013, 2014, 2015). The project's six key findings were: (1) Most young people do not have high science aspirations, (2) Most young people do not have negative views of school science and scientists, (3) family *science capital* is key to science aspirations, (4) most students and families are not aware of where science education can lead, (5) the white male, middle-class image of science careers is problematic for the science aspirations of many students, and (6) the "brainy" image of scientists and science careers puts many young people off of considering a career in the sciences (Archer et al., 2013).

The key findings of the ASPIRES project are directly relevant to this study. For example, the third and fourth key findings of the ASPIRES project resonate with the information presented in Section 1.3.3, which suggested that Latino families in East Los Angeles have fewer connections to science relative to most other communities in the greater Los Angeles area. The fifth and sixth key findings connect with this study through the position of Latinos in U.S. society, highlighted in Chapters 1 and 2 of this thesis. Thus, while recognizing that the context of the current study and the U.K. are very different, one aim of this research was to determine

whether the ASPIRE findings were replicated[17] among the students in East Los Angeles. Further, it is precisely the current study's understanding that the context of the study is central to shaping science aspirations that leads to further consideration of student background characteristics.

2.5.4 Background characteristics associated with science aspirations in East LA

The literature reviewed to this point has established that certain student demographics characteristics (e.g., ethnicity, gender, and socioeconomic status) are associated with science-related attitudes and aspirations. However, the layers of societal positioning in East Los Angeles suggest that understanding the underrepresentation of Latinos in the sciences requires the consideration of factors additional to those examined above. That is to say, accounting for additional background characteristics may be an important part of understanding science aspirations in East Los Angeles. Thus, given the literature reviewed, as well as this researcher's background and professional experience in East Los Angeles, two student demographics in addition to gender and socioeconomic status[18] were theorized to influence science aspirations in East LA: generation of immigration and home language use.

2.5.4.1 Generation of immigration and segmented assimilation

Previous research has shown generation of immigration to be associated with the academic achievement of Latino students (e.g., Eamon, 2005; Portes & MacLeod, 1996) and, as noted in the introduction, East Los Angeles is a gateway community for Latino immigrants in the U.S. Consequently, as the literature reviewed established a link between academic outcomes and aspirations (see Section 2.4.2), it was considered appropriate to include a measure of immigration generation as a predictor of science aspirations.

The theory of segmented assimilation (Portes, 1996; Portes & Zhou, 1993) offers a useful perspective for understanding differences in academic outcomes between students of different

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[17] As Cohen, Cohen, West, & Aiken (2003) point out "Replication is essential to scientific progress" (p. 13).
[18] Ethnicity was not investigated in the current study due to the homogeneous ethnic makeup of the East Los Angeles samples: greater than 95% Latino.

generations of immigration: the theory suggests different immigrant groups assimilate into distinct segments of society. That is to say, segmented assimilation theorizes certain groups in the U.S. (i.e., Latinos) get stopped in their assimilation to middle-class economic status, instead following the path of "downward mobility". On this path, immigrants assimilate into poorer segments of society, adopting the sociocultural values of that segment. Segmented assimilation is articulated in contrast to "selective" assimilation (i.e., Korean-Americans and other East Asians) and "straight-line" assimilation of earlier generations of "White ethnics" such as Jews and Italians (Portes, 1996; Portes & Zhou, 1993).

The theory of segmented assimilation applied to this study suggests that second-generation students in East Los Angeles will likely have undergone downward assimilation. The downward assimilation of these students would result in, for example, lower science aspirations compared to first-generation students. Thus, an inverse relation between science aspirations and immigration generation status was expected within the East Los Angeles samples.

2.5.4.2 Home language use

Previous research has shown that academic outcomes for Latino children are associated with home language use (e.g., Eamon, 2005; García-Vázquez et al., 1997; Lee, 2005). For instance, Eamon (2005) analysed data from of the 2000 U.S. National Longitudinal Survey of Youth (NLSY) in order to identify social-demographic characteristics that influence Latino youth academic achievement. Eamon (2005) found the children of Latina mothers who reported no English language problems scored significantly higher on standardized reading and math achievement tests, compared to Latino children whose mothers reported English language problems and spoke mainly Spanish at home. In discussing the finding, Eamon (2005) suggests that parents less fluent in English are likely to be ill prepared to be involved in their children's academic activities at home, which in turn resulted in lower academic outcomes. On the other hand, some research has found that immigrant Latino parents who maintain Spanish use at home are more likely to hold consistently higher academic aspirations for their children, in comparison to Latino parents who do not similarly maintain Spanish use at home (Raleigh & Kao, 2010). Thus, given the associations between home language use, academic

achievement, and aspirations found in the literature reviewed above, home language use was included in this study as a predictor of science aspirations.

2.6 Summary of the Literature Review

The literature reviewed in this chapter demonstrates the underrepresentation of Latinos in education in general, the STEM fields more specifically, and the sciences particularly. Drawing upon the work of Bowles and Gintis, this chapter suggests that the nature of the U.S. school system acts to reproduce existing inequalities in society, lowering the science aspirations of marginalized groups. This chapter drew on Bourdieu's ideas concerning social positions and the reproduction of social inequalities to suggest that programs designed to stimulate and maintain interest in future science careers at the school level should account for the context of the intervention (e.g., Latinos in East Los Angeles). As well, this chapter suggests that science-related interventions should account for factors research has shown to be associated with aspirations towards a career in the sciences. The literature reviewed in this chapter is in agreement that middle school years are crucial in shaping science aspirations. Nonetheless, the literature reviewed suggests that it is yet unclear which set of factors associated with science aspirations are most influential in secondary school years; thus, further research clarifying influences on science aspirations is needed. Lastly, this chapter suggests that a unique set of influences shape the science aspirations of urban Latino youth during middle and high school years. However, an empirical study specifically aimed at exploring the science aspirations of urban Latino secondary students does not appear to have been carried out to date. The current study was designed to fill this gap in knowledge.

CHAPTER 3 METHODS

3.1 Introduction

This study was designed as a systematic empirical study of science-related aspirations and attitudes among 6th and 9th grade public secondary school students in the East Los Angeles (East LA) area of California, U.S. As explicated in the literature review, there is a historic and ongoing underrepresentation of Latinos within the STEM fields in California, particularly within the sciences. The presence and persistence of Latino underattainment in the STEM fields, as well as the desire to understand what drives Latino underattainment in the sciences, provide the rationale for a systematic study of science aspirations among Latino students.

This research takes a sociocultural perspective on science education, viewing "science, science education, and research on science education as human social activities conducted within institutional and cultural frameworks" (Lemke, 2001, p. 296). In other words, this approach situates individual agency within the context of the constraints of the capitalist economy, class, and racial and ethnic categorization of the United States. Specifically, taken as theoretically prior is the idea that the economic set-up and class basis of the U.S. structure both the organization of education and its consequences for individual students (e.g., Bowles & Gintis, 1976). These ideas are also consistent with the work of sociologists Bourdieu and Passeron (1990), particularly their concepts of *habitus* and capital. *Habitus* has been described as the "dispositions that predispose a person to view reality in certain ways and not in others, without necessarily being conscious of them and without having been formally taught or directed in those ways" (English & Bolton 2015, p. 51). In this study, the neighbourhood – East Los Angeles – is theorized to some extent structure students' (and their families') dispositions towards science. In turn, students' *habitus* will interact with their cultural, economic, and social capital to influence student's aspirations in the field of science. Lastly, this thesis draws upon Koballa's (1988) framework linking science-related attitudes to science aspirations.

Applying the above theoretical priors to the questions posed in this research yields a theoretical perspective for analysing the science aspirations of Latino youth in East Los Angeles. Utilizing this theoretical perspective requires accounting for structural factors (e.g.,

class, ethnicity, gender, immigration generation) that influence and shape a person's attitudes and self-assessments of what is possible in their life. Consequently, in order to apply this theoretical perspective, the research design of this study included measures of both science-related attitudes and background characteristics (e.g., science self-concept, immigration generation).

This chapter begins by enumerating the substantive research questions. Next, the research design of the study is outlined. Following is a description of the characteristics of participating schools and students, together with the explanation of the sampling strategy. Then, the data collection instruments are detailed. Ethical considerations are discussed next, addressing protections accorded participants and the security of the data collected. A detailed report of the pilot study follows, which tested the feasibility of measuring science aspirations with the ASPIRES questionnaire in East Los Angeles. Then, the data collection strategy and procedures for the main study are outlined and discussed. Lastly, an overview of the data analysis strategy is presented.

3.2 Research questions

The overarching aim of this study was to explore the science aspirations and science-related attitudes of two groups of students in East Los Angeles: 6th grade science students in middle school and 9th grade science students in high school. The following research questions were examined in this study:

1. What are the science aspirations of 6th grade (age 11 to 12) Latino students in East Los Angeles?

2. What are the science aspirations of 9th grade (age 14 to 15) Latino students in East Los Angeles?

3. Which attitudinal factors predict the strength of science aspirations in the two samples? In particular, what is the role of student engagement in science-related activities outside of school, experiences of school science, family attitudes to science, images of scientists, peer attitudes to science, and science self-concept?

4. What are the associations between science aspirations and gender, generation of immigration, home language use, and socioeconomic status?

5. Are there (cross-sectional) differences in science aspirations between the 6th and 9th grade samples?

3.3 Research design

The five research questions explore associations between and among science aspirations, science-related attitudes, and background characteristics in the context of East Los Angeles. Several validated instruments designed to measure science aspirations in age groups similar to the target population were considered for use in this research. As this study was interested in exploring social, cultural, and economic influences on science aspirations, (e.g., family and peer attitudes to science, school science experiences, socioeconomic status), the survey instrument chosen needed to fulfil specific criteria.

These criteria included well-defined and validated constructs; measures of family, peer, and school influences on aspirations; appropriate grade levels (6th and 9th grade); and length of questionnaire. Several established survey instruments were considered. For example, the 'Relevance of Science Education' (ROSE) questionnaire (e.g., Sjøberg & Schreiner, 2005) was evaluated and found to be simply too long; its use would have placed an excessive time burden on students and teachers. The 'Is Science Me?' (ISME) questionnaire (Aschbacher et al., 2014; Gilmartin et al., 2006) included measures of family science orientation and school science perceptions, but did not include other constructs of interest (e.g., peer influences). The 'What do you think of science' (Kind, Jones & Barmby, 2007) questionnaire had well-defined and validated constructs, appropriate grade level, and length of questionnaire, but also did not include all constructs of interest (e.g., family and peer influences).

The ASPIRES survey instruments, which included measures drawn from the questionnaires above, were selected for use in this study (See Appendix 1). They were designed to explore science aspirations and engagement for the age groups of interest in the current study (11- to 14-years of age). The surveys were developed by the ASPIRES group at King's College, London (DeWitt et al., 2011, 2013, 2014, 2015). These questionnaires met the specified criteria, including all constructs of interest to this study (i.e., family influences, peer

influences, and school science attitudes). The ASPIRES instruments are discussed and evaluated with respect to the current study in greater detail below (see Section 3.5).

3.4 Research setting, participants, and sampling strategy

3.4.1 Research setting

The setting of the current study was composed of the set of contiguous neighbourhoods in Los Angeles, California, U.S., known as East Los Angeles, or East LA (see Chapter 1). Within this area of 286, 222 residents (U.S. Census Bureau, 2015), there are nine middle schools and thirteen high schools. Middle schools typically consist of grade levels six to eight (ages 11 to 14). High schools in the area consist of four grades: nine (ages 14 to 15) to twelve. The public schools[19] in the area are operated by the Los Angeles Unified School District (LAUSD). The largest school district in the state of California, LAUSD serves approximately 700,000 students (LAUSD, 2015). Schools in LAUSD vary substantially with respect to environment, ethnicity, neighbourhood, size, social class, and type. For example, in 2015 about 95% of the students in the East Los Angeles area were Latino, while districtwide the proportion of Latinos was approximately 75% (LAUSD, 2015).

Among the middle schools in East LA, six are public inclusive schools run by LAUSD, two are charter schools[20], and one is a Catholic private middle school. To clarify, inclusive public schools are those schools that accept and educate all age appropriate students that reside within specified geographical boundaries. For the purposes of this study, the research design encompasses the universe of six inclusive public middle schools in the East Los Angeles area (detailed below), focusing on 6th grade students. This set of middle schools accounts for the majority of the enroled population of middle school students in the area. Table 3.1 lists the six middle schools where data collection took place, as well as some pertinent descriptive statistics of 6th grade students at each school.

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[19] Public schools in the U.S. are government operated schools.
[20] Charter schools in LAUSD are non-inclusive, and attendance preferences are set by the state of California. Thus, not all students who wish to attend may be allowed to enrol in a specific charter school (California Department of Education, 2015).

Table 3.1. Descriptive statistics of participating middle schools in 2014-2015.

School[a]	6th grade (N)	Free lunch[b] (%)	English Learners[b] (%)	Ethnicity[b] (%)
Halley Middle School	502	87	14	92 - Latino 2 - White 5 - Asian 1 - Other
Hawking Middle School	526	93	20	99 - Latino 1 - Other
Lorentz Middle School	441	84	19	98 - Latino 1 - Black 1 - Other
Mendel Middle School	471	92	13	98 - Latino 1 - White 1 - Other
Tesla Middle School	311	89	19	72 - Latino 15 - Asian 13 - Other
Thompson Middle School	452	94	21	99 - Latino 1 - Other

Notes: [a]All school names are pseudonyms.
[b]Data sourced from LAUSD (2015).

Among the high schools in East Los Angeles, six schools are inclusive public, five are charter schools, and two are private Catholic high schools. The 9th grade sample drew from students enroled in five of the six inclusive public high schools; this group makes up well over half of all high school students in the area. Table 3.2 lists each of the participating high schools with some descriptive details.

Table 3.2. Descriptive statistics of participating high schools in 2014-2015.

School[a]	6th grade (N)	Free lunch[b] (%)	English Learners[b] (%)	Ethnicity[b] (%)
Brahe High School	523	79	19	99 - Latino 1 - White
Franklin High School	567	79	20	99 - Latino 1 - White
Gibbs High School	533	72	13	92 - Latino 1 - White 2 - Black 5 - Asian
Kirchoff High School	762	94	12	98 - Latino 1 - White 1 - Black
Meitner High School	434	68	18	74 - Latino 1 - White 1 - Black 24 - Asian
Molina High School	302	86	15	99 - Latino 1 - Other

Notes: [a]All school names are pseudonyms.
[b]Data sourced from LAUSD (2015).

This study comprised only inclusive public schools in East Los Angeles for two reasons. East Los Angeles is an area disadvantaged by a multitude of socioeconomic issues (e.g., poverty, high crime, zonal isolation). Consequently, students enroled in public schools in East Los Angeles encounter substantial obstacles to academic success in their daily environments and lived experiences; these include health and safety issues, emotional and social challenges, and acute and chronic stressors (e.g., Jensen, 2009). Such a confluence of disadvantage suggests that the population of students attending inclusive public schools in East Los Angeles is a

population particularly relevant for a study exploring the causes underpinning the underparticipation of Latinos in the STEM fields. Second, it was thought that data gathered from random samples of 6th grade and 9th grade science classrooms in the universe of inclusive public schools in East Los Angeles would be appropriately representative of the area's general 6th and 9th grade population. With this in mind, the target population and sampling strategy are outlined next.

3.4.2 Study participants and sampling strategy

This study set out to explore the science aspirations of Latino students residing in the inner city (urban Latinos). The term "inner city" is used in the United States to refer to the older, poorer, and more densely populated central sections of a city that are typically populated by ethnic minorities (Oxford Dictionaries, 2010) – a definition that applies to East Los Angeles. Attending an urban inner-city school is considered to be one of the of the disadvantages layered on students in East Los Angeles. For example, a 1996 NCES study points out "urban students and schools compare less favourably to their non-urban counterparts on many measures even after accounting for the higher concentration of low-income students in urban schools" (NCES, 1996, p. xi).

The target population of the study consisted of two different age groups in East Los Angeles. The first group was made up of 6th grade middle school students enrolled in science courses, while the second group consisted of high school students enrolled in a 9th grade science course (Integrated Coordinated Science, Biology, or Earth Science). Consistent with the target population of the study, the study sample was drawn from inclusive public middle schools and high schools in the East Los Angeles area of LAUSD. The sampling frame of the study consisted of the same two groups above.

The sampling strategy for the 6th grade students was applied uniformly to all participating middle schools (see Table 3.1), detailed here. Schools were contacted by the researcher, either in person or via email, with an invitation to participate (see Appendix 2). Once contact had been established, a meeting was arranged with the school's principal in order to gain permission for access to the school. Once access was granted, a list of the 6th grade science

teachers was obtained from the school's Counseling Office (pastoral team). Random selection of the sample occurred at the level of the teacher; this was carried out by randomly selecting every other teacher on an alphabetical list of science teachers at the participating school. An alternate way of collecting data would have been to randomly select a number of students at a particular school; however, this would have been considerably more disruptive to lessons and problematic to implement. Selected teachers were contacted and sent an (opt-in) invitation letter (see Appendix 2); if the teacher did not respond or declined to participate, another teacher was randomly chosen. Once a teacher agreed to participate, all the science classes taught by that teacher were invited to participate in the survey; the participating teacher was asked to distribute information sheets and consent letters (opt-out) to all their students (see Appendix 2). On a date scheduled by the classroom teacher, the questionnaire was administered with pencil and paper by the researcher[21]. The data collection procedure was designed to minimize disruptions to student learning (specific details are provided in Section 3.8).

The second sampling frame consisted of students enrolled in a 9th grade science course (Integrated Coordinated Science, Biology, or Earth Science) at an inclusive public high school in East Los Angeles (see Table 3.2). One of the six invited high school – Franklin HS – declined to participate in the study due to scheduling conflicts: standardized testing was taking place at the school during the researcher's requested dates and the dates were unable to be rescheduled. The sampling strategy for the 9th grade sample was identical to that of the 6th grade sample.

3.5 Data collection instruments

The instruments utilized to collect science aspirations related data from participating students were the ASPIRES questionnaires (see Appendix 1). The survey instruments, designed to explore science aspirations and engagement among 10- to 14-year-olds, were developed, tested, validated, and fielded in multiple settings in the U.K. by the ASPIRES research team at

[21] Conducting the questionnaire online was initially considered. However, not all classrooms had uniform access to the internet – excluding this approach.

King's College, London (e.g., DeWitt et al., 2011, 2013, 2014). The constructs are well underpinned theoretically and have proved reliable and valid in the U.K. context (DeWitt et al., 2011). Constructs drawn from the ASPIRES questionnaire, together with items that map onto them, are presented in Table 3.3. Most items in the instrument utilize a Likert-type scale to elicit attitudinal responses. In order to gather specific background demographic data (e.g., ethnicity, gender, parent education level, parent occupation, and generation of immigration), additional items were added to the questionnaire for use in this study (see Appendix 1).

3.5.1 Theoretical underpinnings of the ASPIRES instruments relative to this study

The ASPIRES study in the U.K. was designed to "shed new light on our understanding of how young people's aspirations develop over the 10-14 age period, exploring in particular what influences the likelihood of a young person aspiring to a science-related career" (Archer et al., 2013, p. 1). While also the general aim of this study, the two studies were situated in very different contexts. That is to say, the ASPIRES study was developed and evaluated using U.K. based samples, therefore the dynamics of sociocultural racialization theorized by the ASPIRES group are distinct to the U.K. Thus, one might be sceptical of the extent to which similar outcomes could emerge using the same instrument, but in very different contexts. For instance, Latinos, the largest ethnic minority in the U.S., experience racialization in a way specific to their history of conquest and colonization by the majority White ethnic group (e.g., Flores-González, Aranda, & Vaquera, 2014; Hill & Torres, 2010). Importantly, the location of Latinos in the U.S. racial hierarchy does not have an obvious counterpart in the U.K. context. Thus, an exploratory principal components analysis was expected to determine whether the same component structures emerged from the East Los Angeles data, and how great the congruence would be with DeWitt et al.'s (2011, 2013, 2015) structures. That is to say, in addition to exploring urban Latino science aspirations, one aim of the current study was to ascertain whether or not the ASPIRES instruments could be utilized successfully in a population of students in an educational setting outside of the U.K.

Table 3.3. ASPIRES survey measures with associated items.

Aspirations in science	**Parental support/involvement**
q11b I would like to study more science in the future.	q5b It is important to them that I try my best in school.
q11c I would like to have a job that uses science.	q5d They know how well I am doing in school.
q11d I would like to become a scientist.	q5g They always attend parent conferences at school.
q11e I think I could be a good scientist one day.	**Peer attitudes to science**
Experience of school science	q7a Like science?
q8a My teacher expects me to do well in science.	q7b Think science is cool?
q8b I get good grades in science.	**Peer orientation to school**
q8c We learn interesting things in science class.	q7c Get good grades in science?
q8d I look forward to my science class.	q7d Care about their grades in school?
q8e Science class is exciting.	q7e Encourage you to do well in school?
q8f Studying science is useful for getting a good job.	q7f Are smart?
Interest in science outside of school	**Self-concept in science (negative)**
q2a Go to a museum.	q9a I find science difficult.
q2b Do science activities.	q9b I am not good at science.
q2c Read a book or magazine about science.	**Self-concept in science (positive)**
q2d Visit web sites about science.	q9c I learn things quickly in science class.
q2f Watch a TV program about science or nature.	q9d I understand everything in my science class.
q2e Visit a science center, science museum or zoo.	q9e Science is one of my best subjects.
q2g Talk with someone at home about what I've been learning in school.	q9f If I study hard, I will do well in science.
	q9g I feel lost in science class.
Image of scientists (negative)	q9h I do well in science.
q14e are weird.	**Future job (ambition)**
q14g spend most of their time working alone.	q13a To earn a lot of money.
q14h don't have other interests.	q12g* own boss.
Image of scientists (positive)	q12h* become famous.
q14a can make a difference in the world.	**Future job (social)**
q14b make a lot of money.	q12e* work with others instead of by myself.
q14c have exciting jobs.	q12f* have time for hobbies and other interests.
q14d are smart.	q12j* work with people rather than things.
q14f are respected by people.	q12c* have time for family.
Parental ambitions	**Future job (creating making)**
q5a It is important to them that I get good grades.	q13b To make a difference in the world.
q5c They expect me to go to college.	q12d* work outdoors.
q5e They want me to get a good job when I grow up.	q12i* make, design, or invent things.
q5f They want me to make a lot of money.	q12k* build or repair things using my hands.
Parental attitudes to science	**No association**
q5h My family think science is interesting.	q11a Most girls/boys like the same kinds of things I do.
q5i My family think it's important for me to learn science.	
q5j My family would be happy if I became a scientist.	

Note: * These items do not appear in the ASPIRES2 questionnaire.

While the ASPIRES instruments were determined to be useful and appropriate for the exploratory nature of this study (see Chapter 4), it is important to note one critique of the instrument here. Specifically, several of the self-reported attitudinal constructs included in the questionnaire could simply be proxies for other, more robust measures. For example, perhaps it is educational achievement that is the main factor driving science aspirations, rather than science self-concept or parental aspirations. While recognizing this possibility, the main defence of the constructs is through reference to their theoretical conceptions articulated in Chapter 2, and as discussed further below.

3.5.2 Theoretical considerations of the ASPIRES instruments relative to this study

The theoretical perspectives of this study are consistent with the concept of *family habitus* (Archer et al., 2012) central to the theoretical development of the ASPIRES study. *Family habitus*, based on ideas set forth by Bourdieu, refers to "to the ways and settings in which families operate – as such the concept seeks to go beyond simplistic, conscious forms of identification with science… to also encompass values and everyday practices" (Archer et al., 2012, p. 886). Aligned with the concept, the current study design included additional measures of family level influences theorized to be associated with science aspirations and appropriate for the context of this research (e.g., generation of immigration, home language use – detailed in Chapter 4).

3.5.3 Teacher questionnaire

In addition to the ASPIRES instruments, a teacher questionnaire was developed by the researcher in order to obtain background information from teachers participating in the study (see Appendix 1). Data acquired from this questionnaire was utilized in support of the analysis of student data. Once instruments had been selected for the purposes and context of this research, ethical issues that could arise during the course of this study were considered.

3.6 Ethical considerations

Both the pilot and main study of this research received approval from the Research Ethics Committee at the University of Oxford (CUREC 1A form in Appendix 3). The approved procedure applied in order to obtain informed consent was CUREC 1A Protocol 25. This protocol is used for studies utilizing non-invasive methods with children. The protocol is appropriate for this research due to the age of the children (11- to 14-year-olds) in the study, ages which raised questions about their ability to give free and informed consent. Protocol 25 was applied to this study after risk analysis; the research topic was deemed not to be "risky" and there was no perceived risk of harm to participants or the researcher.

Ethical considerations of this research included maintaining data protection, consent by participants, and participant's lost instructional time. Data were captured, transferred, and stored securely per Protocol 25. No reference to individual students was made within this thesis, and thus anonymity was upheld. All consent forms and individual paper-records are kept in a locked filing cabinet at the researcher's field office. Anonymized data keys are stored separately from the data sets. The anonymized data in SPSS 22 format is securely stored by the researcher on password encrypted storage media. The researcher's supervisors have copies of this data, also password encrypted. Electronic data will be stored indefinitely, while hard copy data will be destroyed five years after the research project ends. The survey questionnaire was estimated by the researcher to take approximately 20 minutes to complete. In order to compensate for lost instructional time, the researcher offered to conduct a "hands-on" science activity for the class, selected (from a list of three activities) by the classroom science teacher. The activity was designed by the researcher, a credentialed classroom science teacher, to be completed in the time allotted by the participating classroom teacher.

This study used "opt-out" recruitment for students, meeting conditions set forth in Protocol 25. The "opt-out" approach was used, with approval of participating schools, to facilitate timely implementation of the questionnaire at the school sites. Informed consent of all participants (principals, teachers, parents, and students) was attained through use of letters of information and consent forms (Appendix 2). It was stressed throughout the research project that participation was voluntary, and that consent could be withdrawn at any time.

While the questionnaires and ethical considerations were appropriate for this study, the ASPIRES questionnaires had not previously been utilized in the U.S. Therefore, a pilot study was carried out in order to determine, among other things, the suitability of the survey instrument for the context of this study.

3.7 Pilot study

A pilot study was carried out in East Los Angeles, California during the month of December 2015. Approval to conduct the study was granted by the Central University Research Ethics Committee at Oxford (see Appendix 3). The objective of the pilot study was to determine the suitability of the ASPIRES questionnaires (developed in the U.K. context) for use with students in East Los Angeles schools. Carrying out the pilot study was useful for identifying contextual differences – words and phrases from the original U.K. instrument unfamiliar or confusing to participants in the U.S. In addition, the pilot study was an invaluable first step for the researcher in understanding the data collection process in East Los Angeles.

3.7.1 Pilot study methods and procedure

The ASPIRES questionnaires were developed, tested and found reliable in the U.K., but it was unclear if the questionnaires could be utilized effectively in East Los Angeles. Therefore, two discussion groups (6th grade and 9th grade) were organized at two East Los Angeles schools (Thompson Middle School and Kirchoff High School). Both schools were recruited via school contacts – both schools had agreed to participate in the main study. Approximately 14 students at each school were recruited by their science teacher to participate in the discussion groups; the participating teacher was asked to distribute information sheets and consent letters (opt-out) to their students (see Appendix 2). The discussions were scheduled to take place during the students' daily 40-minute lunch break[22] in the science teacher's classroom, with the science teacher in attendance. The discussions were primarily aimed at determining to what extent the questionnaires were, or were not, comprehensible to these students.

[22] Lunch was provided by the researcher so that participants would not miss their scheduled meal.

The procedure of the 9th grade pilot study was straightforward. On the scheduled day and time of the 9th grade discussion group, participants were introduced to the researcher by their science teacher. Ten (six females and four males) of the 14 invited students had returned consent forms and were present. The researcher greeted the students and distributed the ASPIRES questionnaire and pencils. As the main objective of the pilot study was to determine whether the questionnaire could be successfully comprehended and completed by students in East Los Angeles, students were asked to complete the questionnaire on their own – with the understanding that any questions would be discussed after all students had completed the questionnaire. The students were asked to write down their start and finish time on the front of their questionnaire. After all students had completed the questionnaire, they were provided with highlighter pens. In order to determine the students' understanding, comfort with, and comprehension of the items in the questionnaire, the researcher next read each survey item aloud; the students were asked to highlight any aspect of the question they did not clearly understand. Each highlighted word, phrase or instruction was discussed and the students were encouraged to suggest an appropriate replacement for the item. The discussion group was digitally recorded and stored, with the permission of all participating students, their parents, and teachers.

The same procedure described above was planned for the 6th grade ASPIRES questionnaire discussion group. However, on the date scheduled, December 14, 2015, the entire LAUSD was closed down due to a bomb threat. Consequently, the discussion group did not take place.[23] Because the 6th grade students began their winter holiday break the following week, it was not possible to schedule a new date before the end of the term. However, one 6th grade student (the daughter of the middle school science teacher) did agree to complete and discuss the instrument; the findings were consistent with that of the 9th grade group, discussed next.

[23] It is highly unusual for a bomb threat to force closure of the entire LAUSD system, but the date on which the threat was made was within 10 days of a mass shooting in San Bernardino, California – a location within 50 miles of most LAUSD schools. School and city officials were on high alert, given that at the time it was uncertain whether the perpetrators of the San Bernardino attack had acted alone or were part of a coordinated attack against people in Southern California.

3.7.2 Pilot study findings

The average time for completion of the 9th grade group was 14 minutes. The maximum time for completion was 17 minutes, the minimum 11 minutes. The 6th grade student completed the survey in 13 minutes. It should be pointed out that the Y6 and Y9 ASPIRES questionnaires (see Appendix 1) contain small differences in wording and content that reflect the maturity of the students, thus some terms appeared in one version of the questionnaire but not another. Overall, very few items that required a response were left unanswered.

The students in the 9th grade pilot group were enthusiastic and vocal during the discussion groups. Each student was asked if they had highlighted any terms for each item; all highlighted terms were discussed. Note that every student asked why there was no category for Latino, Mexican, or Mexican-American within the survey item that dealt with race and ethnicity (Question 1: *About You*). As a result, the Latino ethnic category was added to the questionnaire for use in the main study.

Table 3.4 lists alphabetically words and phrases that students highlighted as unfamiliar or confusing, the number of students who highlighted the term, and student suggested alternatives. Words and phrases that caused the students confusion generally fell into one of three categories. First, it was clear that certain professions and job titles held no meaning for the students. For example, in the U.S. a "lorry driver" is known as a "truck driver". Second, some terms (e.g., "maths") were understood, but are not used in the U.S. (math or mathematics). Third, some words used in both the U.S. and the U.K. were not understood by many of the East LA students (e.g., "particular"). While the reasons for the first two categories of confusion are easily understood, the causes underlying the third category are less apparent.

Examination of recent standardized achievement scores for the East LA schools provides some insight into the third category of confusion. For example, in 2014 less than half of the students (38%) at Thompson Middle School were classified Proficient or Advanced Basic in English-Language Arts, as evaluated by Standardized Testing and Reporting (STAR) (LAUSD, 2015). This means that only 38% of students met or exceed state standards in the subject, compared to the LAUSD average of 47% and the California state average of 59%

Table 3.4. Frequency of confusing words and phrases in the ASPIRES questionnaires.

Highlighted term or word	6th (N = 1)	9th (N = 10)	Student suggested alternatives
bin man	1	n/a	
brainy	1	8	
casual worker	0	2	
caterer	0	5	
Design & Technology (D&T)	n/a	3	
dinner lady	1	n/a	
enthusiastic	n/a	3	passionate
fitter	1	9	
general labourer	0	6	
househusband	0	1	
ICT	n/a	9	
Is English your first language?	0	1	
local government employee	0	3	
lorry driver	1	8	
male carer	0	3	
marks	1	7	
maths	0	2	
odd	1	8	strange, weird
parents' evenings	0	2	parent conference
particular	0	10	
qualifications	1	n/a	
run or work in business.	0	1	
STEM club	n/a	5	
surname	0	4	
survey	0	3	
surveyor	0	1	
tick	0	4	
top/bottom set	n/a	8	
U.K.	n/a	3	
Which town was your Year 6 school in?	n/a	3	
works in the arts	0	2	

(LAUSD, 2015). Similarly, at Kirchoff High School, just 42% of students were classified as Proficient or Advanced Basic in English-Language Arts in 2013-14, compared to the LAUSD average of 49% and the state average of 54% (LAUSD, 2015).

In summary, the pilot study testing the administration, comprehension, and completion of the ASPIRES questionnaire provided sufficient evidence that the instrument could be successfully completed by students in East Los Angeles. Given the relatively low levels of English-Language Arts proficiency and the high proportion of English Learner (EL) students in the pilot study, it was not surprising some participants had difficulty with words and terms such as "enthusiastic". However, this issue was relatively minor in comparison to the lack of familiarity with the U.K.-specific terms. That is to say, the principal obstacle to using the questionnaires in the U.S. were descriptive terms specific to the U.K. context (e.g., "bin man"). Consequently, confusing U.K. terms were replaced with their U.S. equivalent in the main study; words and terms that few students indicated a lack of familiarity with were not changed. The 14 terms that were replaced in this study are listed in Table 3.5. The final version of the 6th grade and 9th grade modified ASPIRES instruments used in the main study are located in Appendix 1. Once the pilot study had been successfully completed and the ASPIRES instruments appropriately modified, the data collection strategy of the main study was designed.

Table 3.5. ASPIRES questionnaire words and terms together with replacements.

ASPIRES word or term	*Replacement word or term*
bin man	trash man
brainy	smart
dinner lady	lunch lady
fitter	assembler
general labourer	day laborer
ICT	IT
lorry driver	truck driver
marks	grades
odd	strange
surname	last name
tick	check
top/bottom set	honors/sheltered class
U.K.	U.S.
Which town was your Year 6 school in?	What was your 6th grade school?

3.8 Data collection strategy, implementation, reflections, and example

3.8.1 Data collection strategy and implementation

The data collection strategy – designed to be efficient while minimizing disruptions to daily educational processes – is described here. Generally, information sheets with consent forms were sent to parents of participating students with the choice to "opt-out" of the study one week before the scheduled survey date; students were asked to return the forms the day before the survey. On the day of the survey all students, with the exception of students whose parents chose to opt-out, were invited to participate in the study; it was emphasized that participation was voluntary. As the survey was conducted using paper and pencil, questionnaires and pencils were provided by the researcher. The time allotted for the questionnaire was nominally 20 minutes, although students were given as much time as they needed to finish. Each classroom teacher was asked to complete a teacher questionnaire during the same time frame.

In this way data from the ASPIRES questionnaire was collected from 539 6th grade students at six East Los Angeles public middle schools. The ASPIRES2 questionnaire was successfully completed by 428 9th grade students at five public high schools in East Los Angeles. Table 3.6 and Table 3.7 provide basic descriptive information about the survey population from each of the participating schools. To clarify some terms in the tables, English Learners (EL) are students for whom English is not a native language (LAUSD, 2012). Resource Specialist Program (RSP) refers to the "support students with disabilities in accessing and progressing in standards-based core curriculum" (LAUSD, 2004, p. 1) receive from the school district. In order to provide useful context to the data collection procedure of this study, issues with and reflections on the entire process are presented next.

Table 3.6. 6th grade sample descriptive data by school.

School[a]	Sample (N)	Boys (N)	Girls (N)	EL[b] (N)	RSP[c] (N)	Ethnicity (%)
Halley MS	97	41	56	23	1	93 - Latino 3 - White 1 - Other
Hawking MS	118	58	60	32	5	112 - Latino 4 - White 2 - Other
Lorentz MS	62	30	32	20	5	60 - Latino 2 - Other
Mendel MS	86	34	52	21	3	85 - Latino 1 - White
Tesla MS	89	39	50	15	1	82 - Latino 2 - White 5 - Other
Thompson MS	87	43	44	25	3	77 - Latino 2 - White 8 - Other
Grand Total	539	245	294	136	18	509 - Latino 12 - White 18 - Other

Note: [a]All names are pseudonyms.
[b]EL ≡ English Learners.
[c]RSP ≡ Resource Specialist Program.

Table 3.7. 9th grade sample descriptive data by school.

School[a]	Sample (N)	Boys (N)	Girls (N)	EL[b] (N)	RSP[c] (N)	Ethnicity (%)
Brahe HS	85	36	49	12	4	80 - Latino 5 - Other
Gibbs HS	63	32	31	16	6	60 - Latino 3 - Other
Kirchoff HS	97	38	59	10	1	92 - Latino 5 - Other
Meitner HS	87	51	36	15	4	67 - Latino 2 - White 14 - Asian 4 - Other
Molina HS	96	43	53	12	3	90 - Latino 4 - Black 2 - Other
Grand Total	428	200	228	65	18	389 - Latino 2 - White 4 - Black 14 - Asian 19 - Other

Note: [a]All names are pseudonyms.
[b]EL ≡ English Learners.
[c]RSP ≡ Resource Specialist Program.

3.8.2 Reflections on the implementation of the data collection strategy

While the sampling strategy planned for responses from approximately 600 6th grade students and 600 9th graders (100 at each school for a total of 1,200 students), the total number of surveys actually administered was somewhat lower (N = 967). This outcome was due to several factors, including smaller class sizes than anticipated, smaller school populations than anticipated (the result of recent charter school enrolments), and a limited time frame within which to gather data. For example, the questionnaire was administered during late spring of 2016, which overlapped with California's standardized testing schedule[24]. As a result, the majority of participating middle schools and high schools provided research access only after standardized testing was completed. Further, as participation was voluntary, the researcher could suggest dates, but individual teachers made final decisions on access. In the planning stages of the research it was hoped that, if necessary, the researcher could return to collect additional data. This too was not possible due to the scheduling constraints of the participating schools and teachers. Lastly, as a result of the limited time frame within which to collect data, the researcher could not gain timely access to one high school – resulting in an (unexpected) deficit of approximately 100 study participants.

Nonetheless, high quality survey data were collected from a sample of middle school (N_{6th} = 539) and high school (N_{9th} = 428) students in East Los Angeles. The total number of participants for the 6th grade and 9th grade samples provided sufficient degrees of freedom for the robust estimation of both population parameters and frequency distributions, as well as coefficients on independent variables of interest in inferential models (see Chapter 4 and 5).

3.8.3 Reflections on the data collection (6th grade)

Several general characteristics of the school sites, science classrooms, and science teachers emerged from observations made by the researcher during the data collection process. For example, although the schools were well maintained and quite clean, graffiti was observed at each site – despite several schools employing a full-time worker dedicated to graffiti removal.

[24] The overlap was not anticipated. The California Department of Education chose to implement a new set of standardized tests for the 2015-2016 school year later than initially scheduled.

For instance, the school sites generally felt safe and secure: every school had a police officer (armed with a pistol) assigned to it full time, as well as a minimum of four campus security aides.

Casual observations made by the researcher suggested that the science classrooms all had sufficient numbers of books and school supplies. Class furniture (desks and chairs) were not uniform, but in (mainly) working condition. Generally, the classrooms were cramped and overcrowded. For example, Mr. Avellan's 6th grade classroom at Thompson Middle School had 35 students; it was difficult to walk between desks without inadvertently bumping a student.

No middle school science teacher taught in a science specific classroom, making teaching science that much more difficult for the teachers. For example, only two of the middle school science classrooms had a sink in the classroom. According to the teachers, limited science facilities were the norm in the area's schools (all the middle schools were built more than 70 years ago). This would tend to support at least the first part of Wright's (2012) assertion that "low-income minority students are subjected to inferior facilities, less adequate teachers, and an incomparable curriculum" (p. 1615), compared to their counterparts in more affluent areas. Unsurprisingly, due to the limited facilities, complications arose in several of the schools that chose to participate in the hands-on science activity conducted by the researcher. Specifically, the activities required water; however, as noted above several classrooms had no water source (frequent trips to nearby water fountains remedied the situation).

Eleven of the twelve participating 6th grade classes were taught by male teachers. All teachers were aged 30 and above. Ten of the twelve teachers had been at their schools for over five years, with five having served over ten years – counter to the notion that schools located in low SES neighbourhoods experience a "revolving door" effect of high turnover in teaching staff (e.g., Hanushek, Kain, & Rivkin, 2004). Nine of the 12 teachers were Latinos, two more were White, and one Asian-American. The high proportion of Latino teachers is worth noting, as some research has found that students perform better academically when matched with a teacher of similar ethnicity (e.g., Saft & Pianta, 2001); on the other hand, a 2009 longitudinal

study by Buddin and Zamarro conducted within LAUSD showed little evidence for this proposition (Buddin & Zamarro, 2009).

None of the 6th grade science teachers had majored in a science discipline at university. This fits a pattern often observed in schools located in low socio-economic neighbourhoods (e.g., Buddin and Zamarro, 2009). More specifically, Buddin and Zamarro (2009) point out that "urban districts and schools in low-income urban neighbourhoods often employ teachers with low qualifications and weak academic credentials to instruct disproportionate shares of low income and at-risk students" (p. 103).

Without exception the teachers and students were pleasant and welcoming. With a few exceptions, classroom management was not an issue – students were generally polite and respectful. A specific example of school site data collection procedures at one of the schools from which the above observations and reflections were drawn is provided next.

3.8.4 Example of school site data collection: Thompson Middle School

Although school site procedures – and the researcher's experiences – varied somewhat from school to school, the following description is representative of this study's data collection procedure on the day of a survey.

Day of the survey

The survey was scheduled for a Friday in April, 2016 – chosen by the classroom teacher, Mr. Avellan. The researcher arrived at approximately 30 minutes before the start of the school day at Thompson Middle School in order to prepare for the survey. Mr. Avellan taught three double lessons of combined 6th grade math/science classes daily. Science class followed math class; therefore, the survey was administrated during second, fourth, and sixth period. Each period was 55 minutes in duration.

After normal class starting procedures for each period (attendance, announcements, etc.) were carried out by Mr. Avellan, the researcher was presented to the class. The researcher briefly

introduced himself and the study. A questionnaire and two pencils were distributed to each student participating in the survey.

In order to maintain a pace that would allow for completion of the survey in the allotted 20 minutes, the researcher read the questionnaire aloud and asked the students to fill in their responses. The students were encouraged to ask for clarification of questions or items that were unclear to them. These questions generally involved terms unfamiliar to native Spanish speakers and/or students with limited English proficiency. In these cases, the researcher would translate or find a suitable alternative term in English (the researcher is a native Spanish speaker). Upon completion of the questionnaire, students were asked to close the questionnaire and place their pencils down. After the researcher ensured all students had finished, the questionnaires were collected.

Upon completion of the survey, per Mr. Avellan's request, the researcher conducted a hands-on science activity involving lenses and the scientific method; it was thought the activity would compensate to some extent for missed instructional time. The activity was approximately 45 minutes in duration. All materials for the activity were provided by the researcher.

Post survey

Mr. Avellan was asked and subsequently completed a teacher questionnaire. As well, Mr. Avellan was asked and agreed to provide information regarding end of term grades for participating students to the researcher.

Summary

During second period, 35 students (14 boys and 21 girls) were administered and completed the survey; second period had 9 English Learners (EL) and one RSP (Resource Specialist Program) student. During period four, 31 students (14 boys and 17 girls) were administered and completed the survey; period four had 7 EL students and two RSP students. During period six, 31 (18 boys and 13 girls) students were administered and 30 completed the survey (one boy left home early); period six had 9 EL students and no RSP students.

No significant problem was encountered during the administration of the questionnaire. However, it must be noted that, due to the rambunctiousness of several students, the survey required approximately five minutes more than the anticipated 20 minutes to complete. As well, the students kept six of the researcher's pencils and one test tube through the course of the day. Once data collection at this school was completed, the data were analysed – together with data from the other school sites – as described in the next section.

3.9 Data analysis overview

The analysis of the data collected from 539 6th grade students and 428 9th graders in public inclusive secondary schools in East Los Angeles was designed and carried out in three stages (detailed in Chapters 4, 5, and 6). The first stage involved a principal components analysis (PCA) of items drawn from the questionnaire. The PCA was conducted in order to determine the component structure of the survey data and provided discrete and reliable measures of key attitudinal constructs. The PCA analysis directly addressed the first two research questions – the science aspirations of 6th grade and 9th grade students. Following the dimensionality analysis, background covariates of science aspirations among the two East Los Angeles samples were generated. Specifically, items drawn from the student questionnaire measuring demographic characteristics were utilized to create student background measures of gender, generation of immigration, home language use, school attended, and socioeconomic status. ANOVA and analysis of means were conducted using the background variable in order to partially address the third and fourth research questions.

A set of multiple regression analyses were carried out in the second stage of the data analysis. Measures of science-related attitudes and background characteristics were specified as predictors of science aspirations in hierarchical multiple linear regression models. The results of the regression analyses provided insight into the impact of student attitudes on science aspirations. The regression analyses also provided clarification of the relation between science aspirations and student characteristics, demonstrating the simultaneous and combined effect of each of the explanatory variables. This second stage of the analyses answered the third and fourth research questions of this study.

The third stage of the data analysis compared and contrasted the results of the data analysis of the 6th and 9th grade samples. Specifically, this stage of the analysis examined response patterns on the items that comprised the science aspirations measure, as well as the outcomes of the regression models. The third stage analysis answered the fifth research question of this study.

3.10 Summary of the Methods

Implementing the methods detailed in this chapter resulted in the successful collection of rich and detailed data from a randomly selected sample of 6th grade and 9th grade students in East Los Angeles. Parts of the methods were tested in a pilot study, demonstrating the feasibility of gathering data using the ASPIRES instrument among Latino students in East Los Angeles (based on the results of the pilot study, certain U.K.-specific terms used in the instruments were modified). Randomly selected classrooms from public inclusive middle (N = 6) and high schools (N = 5) in East Los Angeles participated in this study. Despite the challenging environment in which students in East Los Angeles schools learn science, this study was able to gather data related to their science aspirations with the successful completion of 539 6th grade and 428 9th grade questionnaires. More specifically, data from a wide variety of individual-level traits and science-related attitudes were collected, in addition to information on family, home life, and socioeconomic status. As well, and in support of the analysis of the student data, demographic data were gathered from participating teachers through the use of a teacher questionnaire. These data collected in the spring of 2016 represent the first known baseline study of science aspirations among Latino secondary students in East Los Angeles, enabling future comparisons of the data in East Los Angeles and beyond. The following three chapters detail the analysis of the data gathered using the methods outlined in this chapter.

CHAPTER 4 GENERATION OF VARIABLES

4.1 Introduction

This chapter presents the first stage of the data analysis, carried out to reduce survey data – acquired by the methods described in Chapter 3 – to a cohesive set of variables theorized to be related to science aspirations. Two categories of variables were generated: student attitudinal constructs and student background characteristics. The analysis in this chapter begins to address the first two research questions of this study: **What are the science aspirations of 6th grade Latino students in East Los Angeles?** and **What are the science aspirations of 9th grade Latino students in East Los Angeles?**

This chapter begins with the description of the principal components analysis (PCA) of the 6th grade survey data, identifying and quantifying attitudinal constructs theorized to be associated with science aspirations. Then the PCA of the 9th grade data is presented. Next, the generation of student background measures is detailed. This chapter concludes with the examination of the *Aspirations in science* component with respect to student background characteristics.

4.2 Principal components analysis of the 6th grade sample

This section details the principal components analysis (PCA) of survey data gathered from the 6th grade students; the analysis was conducted in order to explore the underlying structure of their science aspirations. First, the methods of the acquisition of the data are summarized. Then the assumptions of the analysis are reviewed. Next, the results of the PCA are presented. Following, the PCA solution is analysed with respect to the context of this study. Lastly, some limitations associated with the 6th grade data principal components analysis are examined.

4.2.1 Method summary: Participants, materials, and procedure (as related to the principal components analysis) – 6th grade

Sixth grade students attending inclusive public schools in East Los Angeles participated in this study designed to explore their aspirations for a future in the sciences. The survey instrument used for the 6th grade students (ages 11 to 12 years) was based on the ASPIRES questionnaires (see Appendix 1), examined and evaluated in Section 3.5. The questionnaire was successfully

completed in the main study by 539 6th grade students. Table 3.6 in the Methods section provides basic descriptive information about the survey population from the middle schools that participated in the study. Data collection strategy and procedures were completed as described in Section 3.8.

4.2.2 Data assessment and assumption testing – 6th grade

In order to identify and explore linear dimensions among the items of the questionnaire, a principal components analysis of the survey data was carried out. PCA is a statistical procedure applied to a set of variables for the purpose of reducing data to a smaller set of more easily interpreted "components" (e.g., Field, 2013; Tabachnick & Fidell, 2013). Variables that group as a component are well correlated; in turn, the component is mainly independent of other components formed from remaining variables (Tabachnick & Fidell, 2013). A valid principal components analysis requires that specific assumptions about the data are satisfied. Consequently, the data were assessed and were found to meet assumptions necessary for a reliable PCA (reported in Appendix 4).

4.2.3 Results of the 6th grade principal components analysis

This subsection presents and explains the principal components analyses conducted on data from the 6th grade sample and begins with a review of the initial principal components analysis. Next, the final principal components analysis solution is presented. Following is the reliability analyses of the final solution. This subsection finishes with an analysis of component scores generated from the solution.

4.2.3.1 Principal components analysis of the 6th grade data

A principal components analysis was carried out on 58 survey items in order to obtain an initial set of eigenvalues for components in the data. Sixteen components had eigenvalues over Kaiser's criteria of one. Kaiser's criterion is "a method of extraction in factor analysis based on the idea of retaining factors with associated eigenvalues greater than one" (Field, 2013). The first three components explained 23.3%, 5.5%, and 4.5%, respectively, of the

variance, with the remaining components contributing less than 4% each. In combination, the sixteen components explained 66.5% of the variance in the solution.

In order to determine the number of factors to retain in the PCA, a scree plot of the analysis was examined. A scree plot is a line segment plot showing the fraction of total variance in the data as explained by each principal component, with the components ordered by decreasing contribution to total variance (Tabachnick & Fidell, 2013). Inspection of the scree plot (Figure 4.1) of the initial PCA suggested solutions of three, ten, and fourteen components (Field, 2013). Consequently, solutions with three, ten, and fourteen components were explored using both orthogonal (varimax) and oblique (oblimin) rotations of the factor loading matrix. A ten-component solution with varimax rotation, which explained 62.3% of the variance, was chosen because of (1) clear previous theoretical support of ten of the components that emerged, (2) the inflection point at ten on the scree diagram with subsequent levelling off of the remaining eigenvalues, and (3) insufficient number of primary loadings (two or fewer items) on the remaining six components (components 11-16).

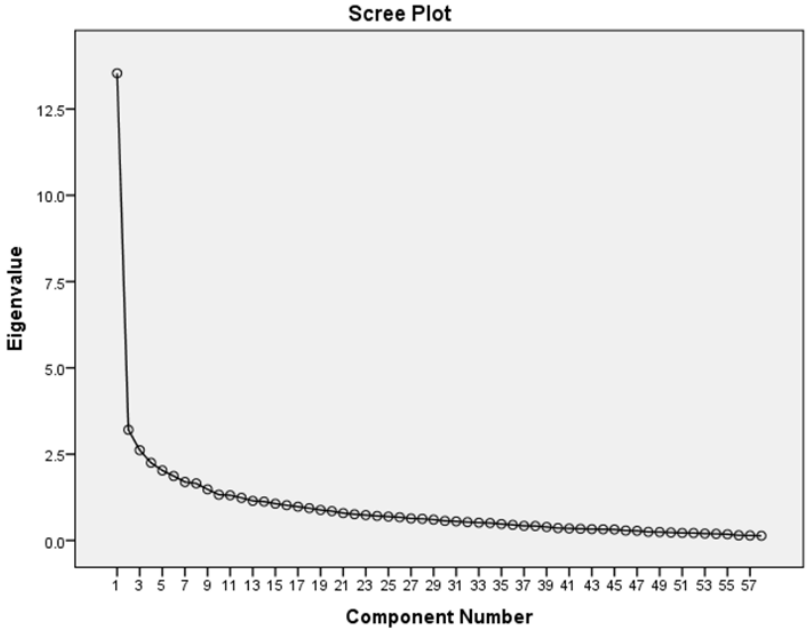

Figure 4.1. Scree plot of initial 6th grade PCA (SPSS 22 output).

Choosing the ten-component solution required dropping 13 items from the analysis. Eight of the 13 items dealt with future job possibilities and did not load coherently onto any one component. Two items, 'q2a Go to a museum' and 'q2e Visit a science center, science museum or zoo', loaded together on the same component and can be easily interpreted as precisely such activities outside of school time. However, these two items were not included in further analyses because "interpretation of factors defined by only one or two variables is hazardous…even under the most exploratory factor analysis" (Tabachnick & Fidell, 2013, p. 651). Similarly, item 'q5g They always attend parent conferences at school' – a single item component – was dropped from the analyses. Lastly, the two items 'q10a Most girls/boys like the same kinds of things that I do' and 'q5d They know how well I am doing in school' were excluded because they did not the meet the criteria of having a primary factor loading of .4 on at least one component (Tabachnick & Fidell, 2013). Once the initial analysis of item loadings was carried out, a final principal components analysis solution was generated.

4.2.3.2 Final principal components analysis

The last phase of the principal components analysis of the remaining 45 items was conducted using both varimax and oblimin rotations. There was little discernible difference between the ten component varimax and oblimin solutions: items grouped together similarly. As a result, and given that the interpretation of orthogonal components is considered less ambiguous (Tabachnick & Fidell, 2013), varimax rotation was preferred for the final solution.

The final ten component solution explained 62.7% of the variance in the variables. Primary loadings for this analysis were over .5, with three exceptions: 'q9e Science is one of my best subjects', 'q9c I learn things quickly in science class', and 'q9d I understand everything in my science class'. The component loading matrix for this final solution is presented in Table 4.1. The components are displayed in order of percent variance accounted for by the component in the final solution. For example, the first component explained 11.02% of the variance and is comprised of five items that measure a student's desire to continue studying science and have a future in science – aspirations in science. The highest loading (.835) for this component occurred on the item 'q10d I would like to become a scientist' while the lowest loading (.505)

Table 4.1. 6th grade factor loadings, communalities, and percentage of variance of principal components extraction with varimax rotation.

Item	C_1[a]	C_2[a]	C_3[a]	C_4[a]	C_5[a]	C_6[a]	C_7[a]	C_8[a]	C_9[a]	C_{10}[a]	
q10d I would like to become a scientist.	.835										
q10c I would like to have a job that uses science.	.760										
q10e I think I could be a good scientist one day.	.741										
q10b I would like to study more science in the future.	.696										
q8f Studying science is useful for getting a good job…	.505										
q8e Science class is exciting.	.452	.654									
q8a My teacher expects me to do well in science.		.650									
q8c We learn interesting things in science class.		.641									
q9f If I study hard, I will do well in science.		.602									
q8d I look forward to my science class.	.470	.562									
q9e Science is one of my best subjects.		.486									
q9b I am not good at science. (Reverse coded).			.793								
q9a I find science difficult. (Reverse coded).			.728								
q8b I get good grades in science.			.703								
q9h I do well in science.			.701								
q9g I feel lost in science class. (Reverse coded).			.570								
q9c I learn things quickly in science class.		.411	.496								
q9d I understand everything in my science class.		.458	.470								
q11d are smart.				.780							
q11b make a lot of money.				.734							
q11a can make a difference in the world.				.664							
q11f are respected by people.				.537							
q11c have exciting jobs.	.499			.537							
q2b Do science activities.					.648						
q2c Read a book or magazine about science.					.687						
q2d Visit web sites about science.					.634						
q2f Watch a TV program about science or nature.					.586						
q2g Talk with someone at home…					.490						
q5e They want me to get a good job when I grow up.						.773					
q5c They expect me to go to college.						.763					
q5f They want me to make a lot of money…						.628					
q5b It is important to them that I try my best in school.						.543					
q5a It is important to them that I get good grades...						.511					
q7d Care about their grades in school?							.723				
q7c Get good grades in science?							.635				
q7e Encourage you to do well in school?							.596				
q7f Are smart?							.566				
q7b Think science is cool?								.738			
q7a Like science?								.722			
q11h don't have many other interests in life.									.712		
q11g spend most of their time working alone.									.665		
q11e are weird.									.661		
q5i My family think it is important for me to learn science.										.646	
q5h My family think science is interesting.										.600	
q5j My family would be happy if I became a scientist…	.438									.563	
	C_1[a]	C_2[a]	C_3[a]	C_4[a]	C_5[a]	C_6[a]	C_7[a]	C_8[a]	C_9[a]	C_{10}[a]	h^2
Eigenvalues	5.07	3.92	3.66	3.02	2.73	2.68	2.00	1.99	1.81	1.77	
% of variance	11.0	8.52	7.95	6.57	5.93	5.82	4.34	4.33	3.94	3.85	62.66
Cronbach's α	.901	.880	.849	.809	.711	.775	.620	.846	.548	.750	

[a]Component label:
- C_1 - *Aspirations in science*
- C_2 - *Experience of school science*
- C_3 - *Self-concept in science*
- C_4 - *Image of scientists-positive*
- C_5 - *Outside of school science*
- C_6 - *Family ambition*
- C_7 - *Peer orientation to school*
- C_8 - *Peer attitudes to science*
- C_9 - *Image of scientists-negative*
- C_{10} - *Family attitudes to science*

was on the item 'q8f Studying science is useful for getting a good job in the future'. As seen in Table 4.1, six items had cross loadings of .4 or above with another component; four of the six cross loaded on the *Aspirations in science*[25] component. For example, the item 'q8e Science class is exciting' had a secondary loading of .452 on *Aspirations in science* and a primary loading of .654 on *Experience of school science.* Similarly, 'q11c Scientists… have exciting jobs' had a primary loading of .537 on *Image of scientists-positive* and a cross loading of .499 on *Aspirations in science*.

The component structures that emerged from the PCA mapped reasonably onto those proposed by DeWitt et al. (2011) for this age group[26]. Consequently, components with structures similar to those theorized and named by DeWitt et al. (2011) were assigned the same label in this thesis. The ten components in alphabetical order are:

- *Aspirations in science*
- *Experience of school science*
- *Family ambitions*
- *Family attitudes to science*
- *Image of scientists-negative*
- *Image of scientists-positive*
- *Outside of school science*
- *Peer attitudes to science*
- *Peer orientation to school*
- *Self-concept in science*

Once the final principal components analysis solution was specified, reliability analysis was carried out on the ten-component solution.

4.2.3.3 Reliability analyses

The reliability of the PCA solution was determined by examining the internal consistency reliability of the subscales (components) using Cronbach's alpha (α). Internal consistency reliability can be thought of as a measure of the average inter-item correlation among items

[25] Component labels and structures are presented later in this section.
[26] In assigning labels to the components, note that many of the component structures, though similar to those proposed by DeWitt et al. (2011), are not entirely the same and this topic is addressed in the discussion of the limitations of the 6th grade PCA.

composing the subscale – an indication of whether items are all measuring the same underlying construct. The alphas are shown at the bottom of Table 4.1. The majority of the alphas were above the generally accepted minimum of .7 (Field, 2013, p. 675), with two exceptions. *Peer orientation to school* had an alpha of .620 and *Image of scientists-negative* had an alpha of .548. Note, however, that it is not unusual for attitudinal scales with relatively few items to have low alphas – especially scales utilized with children (Field, 2013). Therefore, and given that the items mapped well on to their theorized constructs, the two components were retained.

The cross loading of items was also examined as part of the reliability analysis. More specifically, there was no substantial difference in the alpha of any of the ten components if items were removed. Taken together, the above analyses demonstrate that the ten components derived from survey item responses are internally consistent. Once the principal components analysis solution was determined to be reliable, composite scores for the components were generated.

4.2.3.4 Component scores and treatment of missing data

A composite score for each component was calculated and assessed for normality, with the intent of using the scores in a multiple regression analysis of the survey data. Scores were generated by determining the mean score for items that loaded primarily on to a component. Although other methods of deriving scores are possible (e.g., summing scores, factor scores), this method was chosen to ensure that participants who had completed the majority of items (3 of 4, 4 of 5, etc.) on a component – but perhaps not all – would be included in further analyses. As individual item scores generally ranged from one (strongly disagree) to five (strongly agree), component scores correspondingly ranged from one to five. Higher scores indicate a more positive attitude, with scoring adjusted for reverse phrased items (e.g., 'q9b I am not good at science'). Complete descriptive statistics of the component scores are presented in Table 4.2. For example, *Aspirations in* science, had a mean score of 3.10 out of 5 (SD = 0.92). The component *Family ambitions* had the highest mean score of 4.73 (SD = 0.39), albeit with a highly negatively skewed (z_S = -22.78), leptokurtic (z_K =46.27) distribution

Table 4.2. 6th grade component scores and descriptive statistics.

Component	*Mean*	*SD*	*Range*	*Skewness (z score)*	*Kurtosis (z score)*	*N*
Aspirations in science	3.10	0.92	1-5	-0.24	-1.63	537
Experience of school science	3.79	0.88	1-5	-5.24	-2.02	538
Family ambitions[a]	4.73	0.39	1-5	-22.78	46.27	539
Family attitudes to science	3.53	0.86	1-5	-2.19	-0.61	539
Image of scientists-negative	3.00	0.82	1-5	-0.34	0.80	538
Image of scientists-positive	4.14	0.65	1-5	-8.94	9.87	538
Outside of school science	3.00	1.05	1-5	-0.91	-4.27	539
Peer attitudes to science	2.88	0.95	1-5	2.90	-0.24	539
Peer orientation to school	3.15	0.76	1-5	-0.52	-0.93	538
Self-concept in science	3.50	0.77	1-5	-1.57	0.52	539

Note: [a]*Family ambitions* was dichotomized for use in the multiple regression analysis.

(which can be interpreted to mean that the overwhelming majority of students believe their parents hold high ambitions for their future).

Regression analysis assumes that variables are normally distributed (Tabachnick & Fidell, 2013). Note, however, that the standard errors of the skewness and kurtosis – statistics often used to assess normality – are dependent on sample size. Thus, larger samples will tend to have smaller standard errors, which in turn can result in significant *z* scores indicating deviation from normality. Consequently, the normality of a distribution with a sample size larger than 300 is usually assessed through examination of the shape of the distribution (Tabachnick & Fidell, 2013, p. 80). Careful inspection of the histograms (see Appendix 4) of the component scores showed their distributions to be sufficiently normal, with the exception of *Family ambitions* noted above; as a result, *Family ambitions* was dichotomized for use in the regression analysis (detailed below).

Together, the analyses presented in this section demonstrate that the ten unique components derived from 6th grade student questionnaire responses met data assumptions, are internally consistent, and possess (mainly) normally distributed scores. The final ten component principal components analysis solution is analysed and explored next.

4.2.4 Analysis of the 6th grade principal components analysis

Analysis of the ten components extracted from the PCA of the 6th grade data is presented here. To begin, the final solution is reviewed. Next the mapping of items onto theorized constructs is analysed. Lastly, gender differences on component scores are explored.

4.2.4.1 Ten-component structure of 6th grade solution

A principal components analysis with varimax orthogonal rotation resulted in a final ten component structure, including 45 out of 58 survey items initially considered. All ten components clearly mapped onto previously theorized constructs, albeit with some differences noted below; each component was found to be internally consistent. The original set of analysis items was thus restructured into one component representing science aspirations and nine components theorized to be related to science aspirations. The theorization of the component structures was detailed in Section 2.5, and is evaluated with respect to the outcomes of the principal components analysis next.

4.2.4.2 Mapping of items onto components

With the objective of securing a deeper understanding of the 6th grade students' science aspirations, components and their constituent items are analysed here. Drawing upon Koballa's (1988) framework linking science attitudes and aspirations, survey items in this analysis are considered to correspond to student beliefs – beliefs which shape attitudes (see Chapter 2). In turn, components extracted from the PCA of survey items correspond to science-related attitudes. The components are ordered and analysed here with respect to the theoretical perspectives of this study. More specifically, it is thought that influences shaping science aspirations layer onto an individual, with external influences to some extent also shaping internal influences. Consequently, this discussion begins with the two components related to the impact of family on science aspirations.

4.2.4.2.1 *Family ambitions* – 6th grade

Family ambitions in this context refer to a family's ambitions for their child's future. This component was comprised of five items: How much do you agree with these statements about your family…

- q5a It is important to them that I get good grades in school.
- q5b It is important to them that I try my best in school.
- q5c They expect me to go to college.
- q5e They want me to get a good job when I grow up.
- q5f They want me to make a lot of money when I grow up.

Figure 4.2 displays item scores on this component by percentage, with the percentage of the combined categories of 'agree' and 'strongly agree' shown to the right of the 'neither' bar. As seen in the figure, a large majority of students agreed or strongly agreed (mostly over 95%) with these five statements. For example, nearly all students (98.1%) agreed or strongly agreed that their parents wanted them to do their best in school (q5b). It is worth noting that nearly all students (97.5%) agreed or strongly agreed with item 'q5a It is important to them that I get

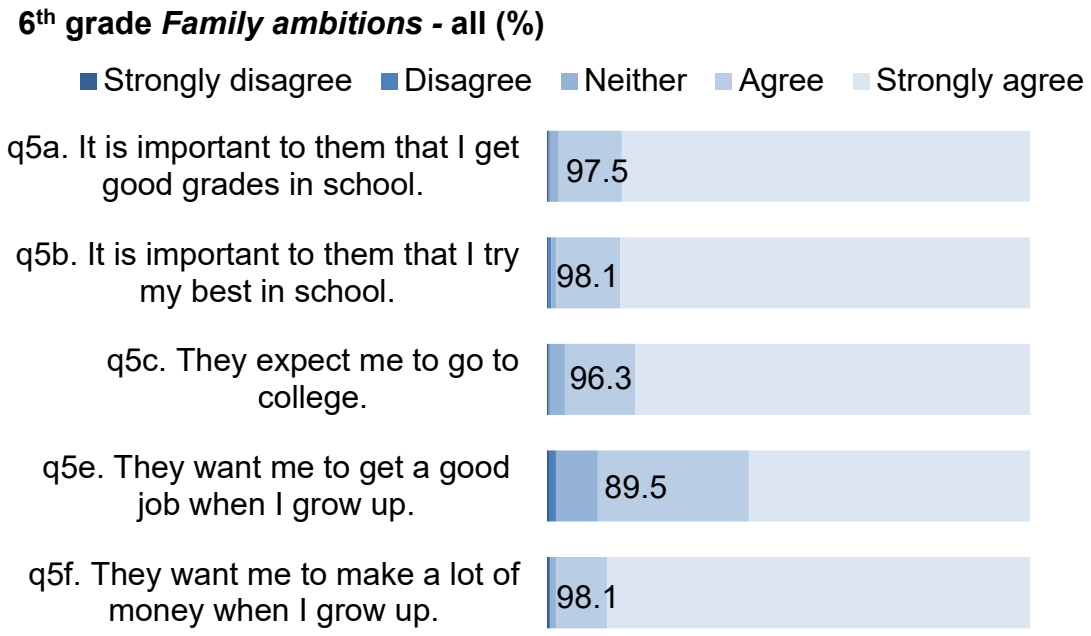

Figure 4.2. Item responses for the 6th grade component *Family ambitions*.

good grades in school', as grades have been found to be strongly linked to science self-concept (discussed below).

Due to its highly negative skew and leptokurtic distribution (see Table 4.2), this component was dichotomized for use in the multiple regression analysis. Specifically, scores of 4.00 and above, corresponding to average responses of 'agree' or 'strongly agree', were assigned a value of one (1). Scores less than 4.00 – corresponding to average responses of 'neither agree nor disagree', 'disagree', or 'strongly disagree' – were assigned a value of zero (0).

4.2.4.2.2 *Family attitudes to science* – 6th

The three items that loaded on this component were: How much do you agree with these statements about your family…

- q5h My family think science is interesting.
- q5i My family think it is important for me to learn science.
- q5j My family would be happy if I became a scientist when I grow up.

Figure 4.2 displays item scores by percentage on this component, with the percentage of the combined categories of 'agree' and 'strongly agree' shown. Examination of the figure shows that *Family attitudes to science* was not nearly as positive as the previous component relating

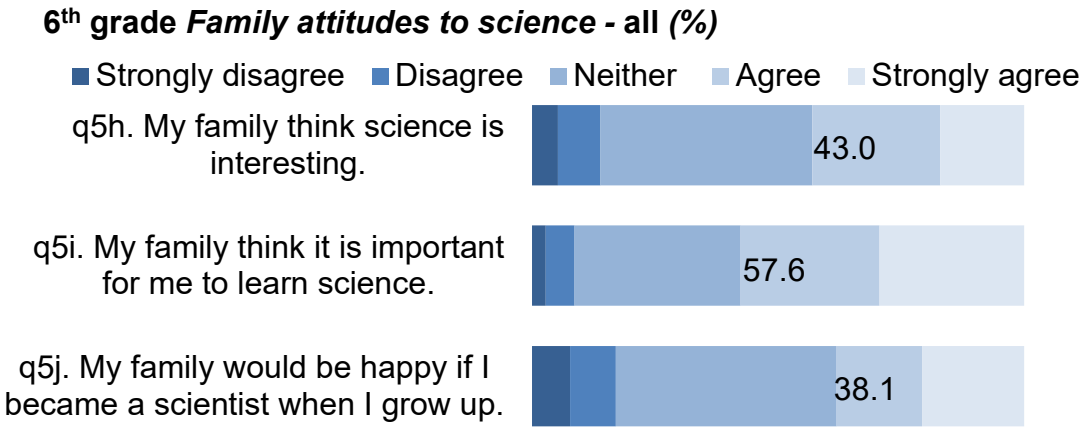

Figure 4.3. Item responses for the 6th grade component *Family attitudes to science*.

to family, *Family ambitions*. For example, much fewer than half of the 6th grade students (38.1%) thought that their parents would be happy if they chose a career in science (item q5j). Note that although the majority of these students (57.6%) believed that learning science was viewed as worthwhile by their families (item q5i), less than half (43.0%) felt science was of actual interest to their family (item q5h). This result is interesting, as family interest in science was theorized to impact a student's "science capital" – which in turn was theorized to impact science aspirations (see Section 2.3); this result is discussed fully in Chapter 8.

4.2.4.2.3 *Peer orientation to school* – 6th

Portes and Zhou (1993) theorized that the mode of incorporation into U.S. society by many immigrant Latinos results in downward assimilation (see Section 2.5). Lowered school-related achievement in later generations is thought to be one outcome of downward assimilation – an outcome that "leads to serious barriers to their chances of upward mobility" (Portes and Zhou, 1993, p. 89). Downward assimilation is thought to occur to a great extent through peer influences; consequently, peer influences on science aspirations are of considerable interest to this study. The peer influence construct, *Peer orientation to school*, was made up of four items: How many of your classmates…

- q7c Get good grades in science?
- q7d Care about their grades in school?
- q7e Encourage you to do well in school?
- q7f Are smart?

Figure 4.4 presents item scores by percentage, with the percentage corresponding to the combined categories of 'nearly all' and 'all' displayed to the right of the 'some' bar. Examination of this component by its constituent items indicates two different student perspectives on peer school orientation. On the one hand, most students thought that all or nearly all of their peers were smart (50.9%) and cared about their grades (51.4%). On the other hand, few students (25.7%) felt that most of their peers encouraged them to do well in school. That is to say, score distributions on this component suggest that most of these students held their peers in high regard academically, but find that the attitude was not generally reciprocated by their fellow students.

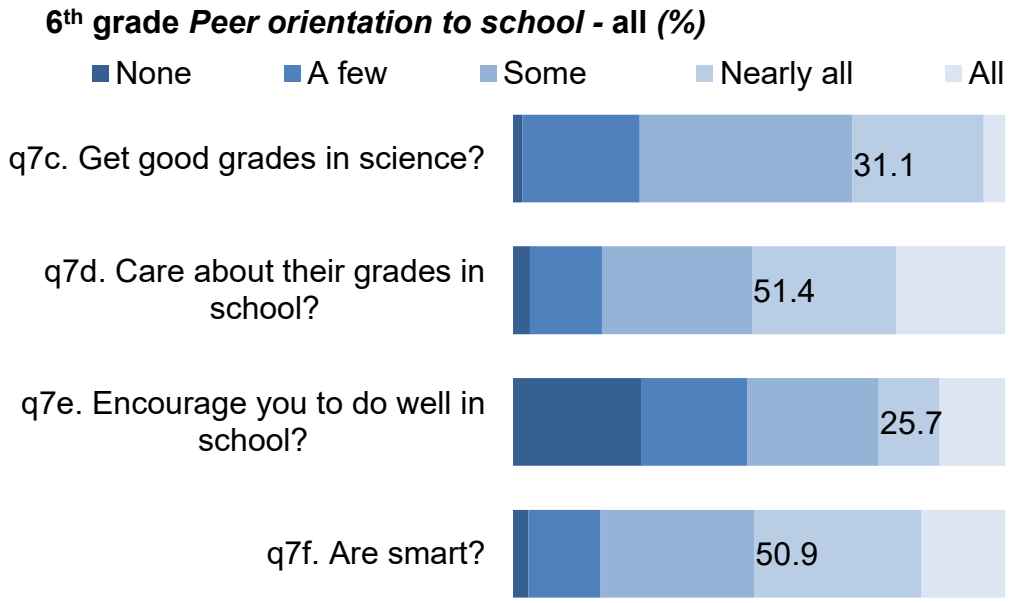

Figure 4.4. Item responses for the 6th grade component *Peer orientation to science*.

4.2.4.2.4 *Peer attitudes to science* – 6th

While composed of just two items, *Peer attitudes to science* was retained in the final solution because of previous theoretical considerations and a satisfactory measure of internal consistency (α = .846). The two items that made up the component were: How many of your classmates…

- q7a Like science?
- q7b Think science is cool?

The distribution of responses in Figure 4.5 suggests that most of the 6th grade students found their peers to be unenthusiastic about science. More specifically, fewer than one in four (23.0%) thought 'nearly all' or 'all' of their peers liked science (q7a), while 37.7% responded 'few to none'; a similar response pattern is observed for item 'q7b Think science is cool'.

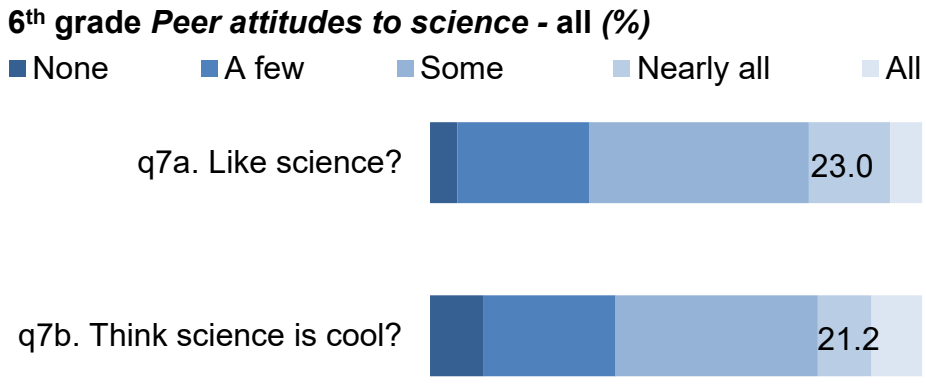

Figure 4.5. Item responses for the 6th grade component *Peer attitudes to science*.

4.2.4.2.5 *Image of scientists-positive* – 6th

The five items that grouped as the measure for the positive image of scientists were: Scientists and people who use science in their jobs...

- q11a can make a difference in the world.
- q11b make a lot of money.
- q11c have exciting jobs.
- q11d are smart.
- q11f are respected by people.

Figure 4.6 displays item scores by percentage on this component, with the percentage of the combined categories of 'agree' and 'strongly agree' shown to the right of the 'neither' band. As can be seen in figure, the response patterns to the items on this component were quite positive. For instance, the vast majority (82.9%) of the 6th grade students agreed or strongly agreed with the item 'q11a can make a difference in the world', with just 1.2% disagreeing or strongly disagreeing. Note that these students seemed to be well aware that a career in science can be lucrative, with more than four-fifths of students (84.5%) agreeing or strongly agreeing

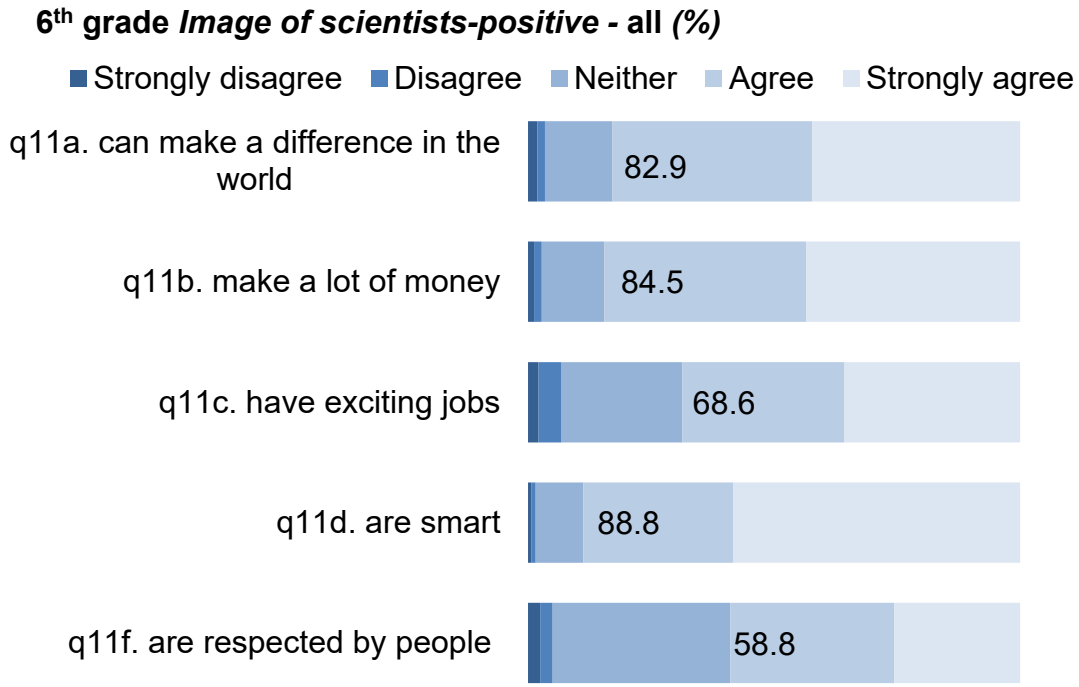

Figure 4.6. Item responses for the 6th grade component *Image of scientists-positive*.

that people in science related jobs make a lot of money – a result pertinent to these students' *Aspirations in science* (below).

4.2.4.2.6 *Image of scientists-negative* – 6th

The component dealing with students' negative image of scientists was made up of three items: Scientists and people who use science in their jobs…

- q11e are weird.
- q11g spend most of their time working alone.
- q11h don't have many other interests in life.

Figure 4.7 displays item scores by percentage. Generally, the 6th grade students did not appear to hold overly negative stereotypes of scientists. As the two *Image of scientist* components are significantly correlated (r (538) = - .089, $p < .05$), it is unsurprising that these results complement the students' positive image of scientists analysed above.

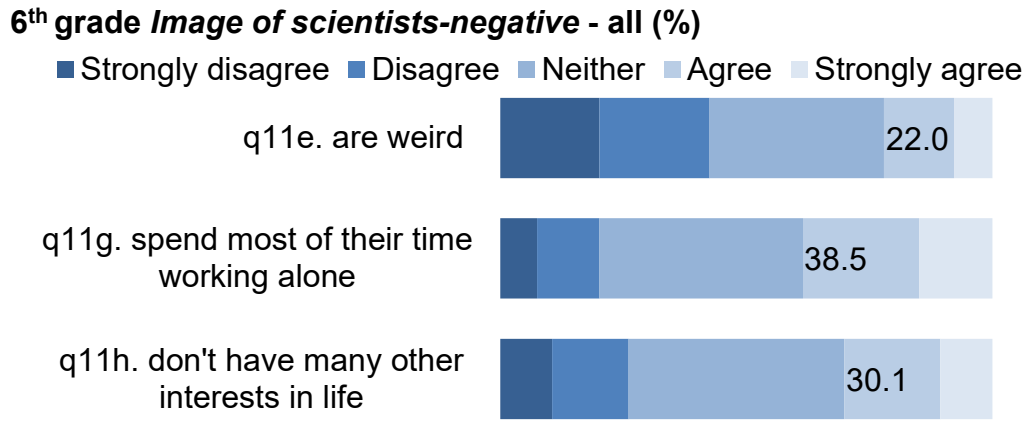

Figure 4.7. Item responses for the 6th grade component *Image of scientists-negative*.

4.2.4.2.7 *Experience of school science* – 6th

The set of six items that dealt with students' experience of school science were: How much do you agree with these statements…

- q8a My teacher expects me to do well in science.
- q8c We learn interesting things in science class.
- q8d I look forward to my science class.
- q8e Science class is exciting.
- q9e Science is one of my best subjects.
- q9f If I study hard, I will do well in science.

Figure 4.8 presents item scores by percentage, with the percentage of the combined categories of 'agreed' and 'strongly agreed' displayed. The responses for this set of items trended positive, suggesting that most of these students enjoyed science class. For example, three of four students (75.8%) agreed or strongly agreed that they learned interesting things in science class (item q8c).

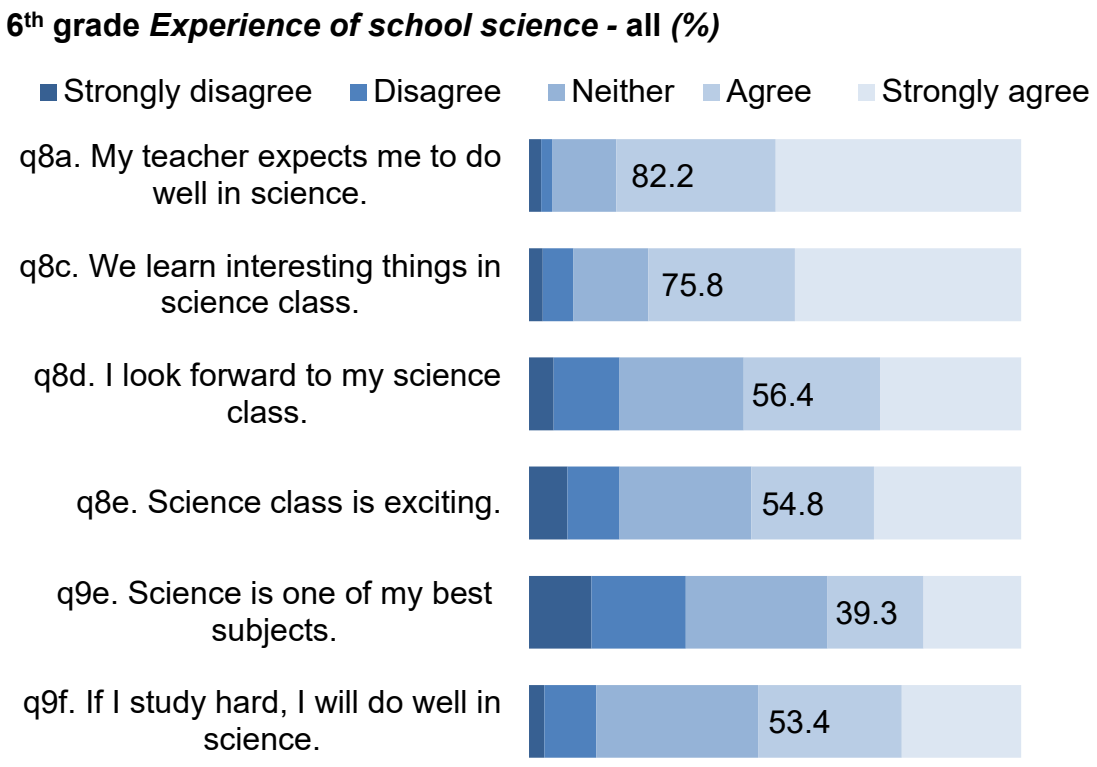

Figure 4.8. Item responses for the 6th grade component *Experience of school science*.

The exception to the overall positive response trend for this component was item ‘q9e Science is one of my best subjects’, with a minority of students (39.3%) agreeing or strongly agreeing with the statement. However, it should be noted that this item was theorized to load on the question stem that measured a student’s self-concept in science, which is the component discussed next.

4.2.4.2.8 *Self-concept in science* – 6th

Self-concept in science is a measure of a student’s perception of their own ability to do science. The seven items that primarily loaded on this component were: How much do you agree with these statements…

- q9a I find science difficult (reverse phrased).
- q9b I am not good at science (reverse phrased).
- q9c I learn things quickly in science class.
- q9d I understand everything in my science class.
- q9g I feel lost in science class (reverse phrased).
- q9h I do well in science.
- q8b I get good grades in science.

The items that make up this component were originally theorized to yield both a positive and negative self-concept component from a six-item question stem that included three “reverse phrased” items; however, all items from this stem loaded onto a single component. Figure 4.9 displays item scores by percentage, with the percentage of the combined categories ‘agree’/‘strongly disagree’ displayed.

The “normal phrased” items had similar response patterns – about half the responses indicating positive self-concept, together with low ‘disagree’ percentages. For example, nearly three in five students (58.5%) agreed or strongly agreed with the statement ‘q9h I do well in science’, while only about one in ten (13.6%) disagreed or strongly disagreed. Only the item ‘q9d I understand everything in my science class’ had a sizable disagree or strongly disagree response percentage (28.3%) – although at the same time more than half the students (53.5%) agreed or strongly agreed with the statement.

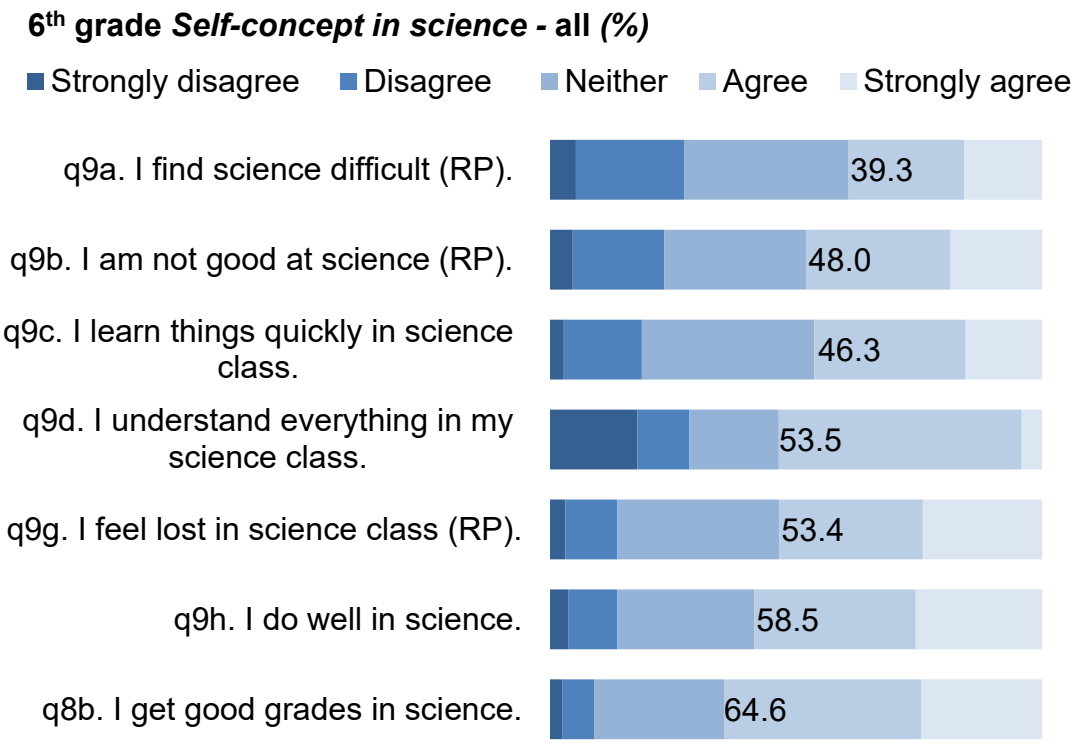

Figure 4.9. Item responses for the 6th grade component *Self-concept in science*.

The "reverse phrased" items 'q9a I find science difficult', 'q9b I am not good at science', and 'q9g I feel lost in science class' all had similar response patterns: sizable percentages of 'agree/strongly agree' and much lower 'disagree/strongly disagree'. For example, more than half the students (53.4%) agreed with the item 'q9g I feel lost in science class', while just slightly more than one in five (13.7%) disagreed or strongly disagreed.

Note that the response patterns of the "normal phrased" items and the "reverse phrased" items appear to be acting in opposition within this component. For example, more than half the students (58.5%) thought they did well in science (q9h), while at the same time more than half the students (53.4%) felt lost in science class (q9g). Nonetheless, the result of Cronbach's alpha test of consistency for this component was quite high ($\alpha = 0.85$); consequently, the component was retained for the regression analysis in this form.

It is worth noting as well that item ‘q8b I get good grades in science’ had the largest positive response (64.6%) and the lowest negative response (9.0%) pattern of this group of items. This type of response pattern (large majority positive, very low negative) was quite similar to that of the items comprising the component *Experience of school science* – the question stem on which this item was theoretically located.

4.2.4.2.9 *Outside of school science* – 6th

The five items that comprised the component measuring participation in science activities outside of school were: How often do you do the following things when you are NOT in school…

- q2b Do science activities (e.g., science kits, nature walks, do experiments).
- q2c Read a book or magazine about science.
- q2d Visit websites about science.
- q2f Watch a TV program about science or nature.
- q2g Talk with someone at home about what I’ve been learning in school.

Figure 4.10 displays item scores by percentage, with the percentage of the combined category ‘yearly’ to ‘never’ shown. Taken together, the responses to these items indicate very low interaction with science-related activities outside of school time for these students. For instance, about half of the students (51.4%) did not engage in science-related activities outside of school more than once a year, while little more than one in ten (13.8%) reported doing so weekly. Similarly, about half (55.9%) of these students visited science websites only about once a year, if ever.

The only response pattern in this group of items that can be considered positive (with respect to science aspirations) was ‘q2g Talk with someone at home about what I’ve been learning in school’. Note, however, that this item was expected to load onto the *Family involvement* component. Similar to the positive and involved response pattern found for *Family involvement*, nearly three out of five (59.1%) students reported talking to family about school learning weekly, with just one in five students (20.1 %) responding ‘never’.

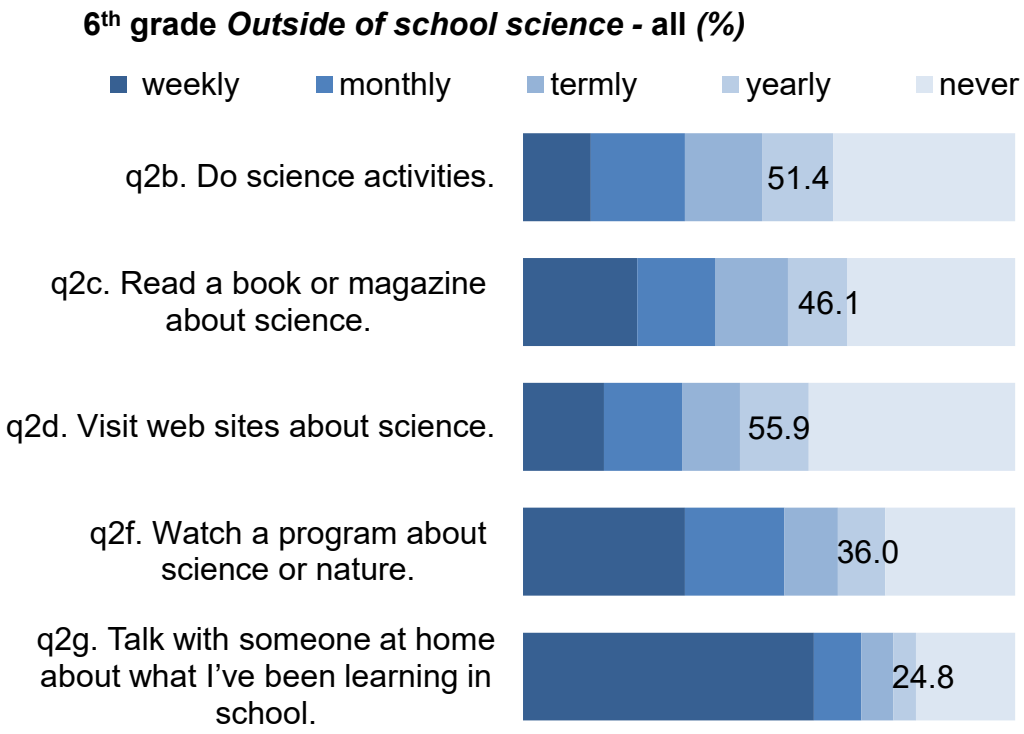

Figure 4.10. Item responses for the 6th grade component *Outside of school science*.

Note as well that the item 'q2e Visit a science center, science museum or zoo' was located on this question stem, although it did not load on this component or emerge in the final solution. Nonetheless, it is worth pointing out that in response to this item nearly half of the 6th grade students (44.1%) reported that they *never* go to museums or science centres. This result is of interest to this study because such visits were theorized to produce science capital, which in turn were theorized to positively influence science aspirations (Archer et al., 2012) – measured in this study by the next and final component.

4.2.4.2.10 *Aspirations in science* – 6th

The dependent variable of this study, *Aspirations in science,* consisted of five items: How much do you agree with these statements…

- q10b I would like to study more science in the future.
- q10c I would like to have a job that uses science.
- q10d I would like to become a scientist.
- q10e I think I could be a good scientist one day.
- q8f Studying science is useful for getting a good job in the future.

Figure 4.11 displays item scores by percentage, with the percentage of the combined categories 'agree' and 'strongly agree' displayed. The response patterns on the items trended rather low for these 6th grade students. For instance, very few (17.1%) agreed or strongly agreed with item 'q10d I would like to become a scientist', while nearly half (47.1%) of the students disagreed or strongly disagreed with the statement. Similarly, only one in three (31.2%) agreed with item 'q10c I would like to have a job that uses science'. In other words,

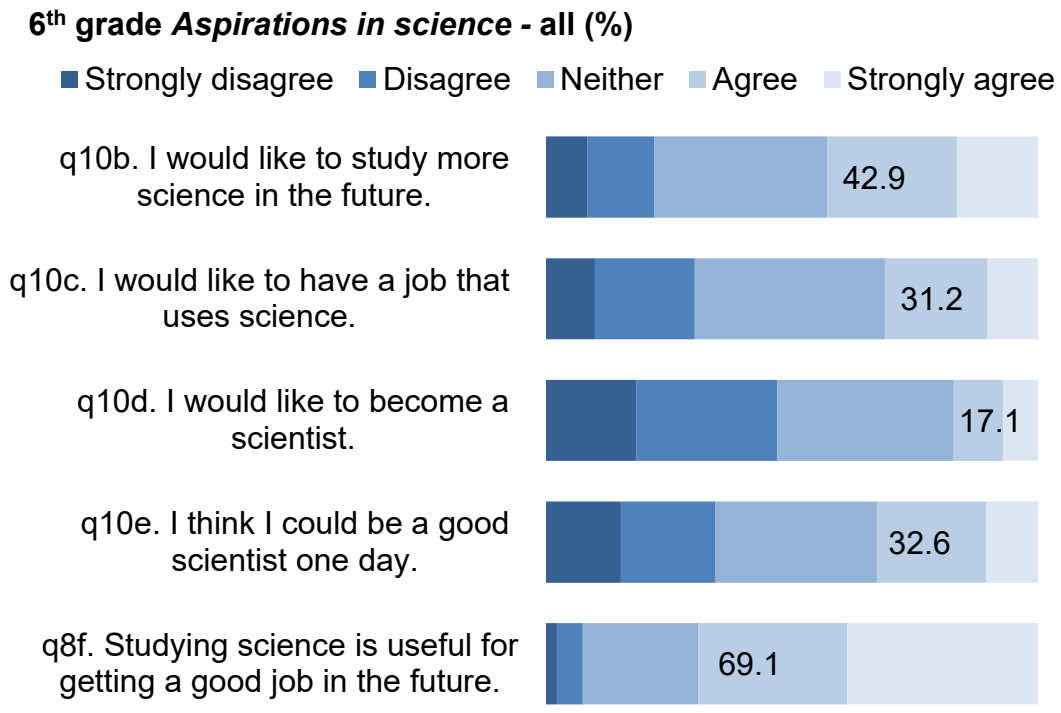

Figure 4.11. Item responses for the 6th grade component *Aspirations in science*.

most of these 11- to 12-year-old students in East Los Angeles do not aspire to a future participating in science.

In contrast, *studying* science was thought to be a very good idea. For example, seven out of ten students (69.1%) agreed or strongly agreed with item 'q8f Studying science is useful for getting a good job in the future'. Further, about half the students (42.9%) agreed that they would like to study more science in the future (item q10b). The strong interest in studying science can be placed into context by noting that nearly four of five students (77.9%) responded 'very much' in response to the survey question 'q6g How much do you want to go to college?'[27]. That is to say, it is quite probable that the appeal of studying science was linked to these students' interest in post-secondary education, given that completion of a specific set of science courses are part of most university admission requirements in the state of California.

Taken together, the responses on the items that comprise *Aspirations in science* suggest that most of these 6th grade students hold a positive view of the usefulness of studying science – together with a rather neutral[28] view towards a future in science. Further insight into these results can be gained by examining the components theorized to be associated with *Aspirations in science* by various student characteristics such as, for example, gender – presented next.

4.2.4.3 Gender differences on component score means – 6th grade

Given the large body of existing "gap" research that exists on science attitudes and aspirations at this age (e.g., Bennett & Hogarth, 2009; George, 2000, 2006; Potvin & Hasni, 2014), one aim of this study was to explore associations between gender and science-related attitudes for this group of students. As seen in Table 4.3, which displays mean scores on the 6th grade components by gender, the 6th grade boys held higher means on seven of the ten components theorized to impact science aspirations. For example, while not significant ($p = 0.43$), the boys

[27] This item was not included in the final PCA from which these components emerged.
[28] Neutral in this case refers to the scale, when summed from items scored 1-5, having a mean score of 3 – which corresponds to an item response of 'neither agree nor disagree'.

Table 4.3. 6th grade component score means by gender.

Component	*Gender*	*N*	*Mean*	*SD*	*p*	*Cohen's d*
Aspirations in science	Boy	245	3.13	0.93		
	Girl	292	3.07	0.92		
	Gap		-0.06		0.426	
Experience of school science	Boy	246	3.86	0.88		
	Girl	292	3.74	0.89		
	Gap		-0.12		0.116	
Family ambitions	Boy	247	4.70	0.43		
	Girl	292	4.76	0.35		
	Gap		0.06		0.103	
Family attitudes to science	Boy	247	3.51	0.86		
	Girl	292	3.54	0.86		
	Gap		0.03		0.691	
Image of scientists-negative	Boy	246	3.04	0.89		
	Girl	292	2.96	0.75		
	Gap		-0.08		0.255	
Image of scientists-positive	Boy	246	4.18	0.61		
	Girl	292	4.11	0.68		
	Gap		-0.07		0.186	
Outside of school science	Boy	247	2.99	1.10		
	Girl	292	3.00	1.01		
	Gap		0.01		0.928	
Peer attitudes to science	Boy	247	2.99	0.99		
	Girl	292	2.80	0.90		
	Gap		**-0.19***		**0.022**	**0.20**
Peer orientation to school	Boy	246	3.22	0.78		
	Girl	292	3.09	0.74		
	Gap		**-0.14***		**0.038**	**0.18**
Self-concept in science	Boy	247	3.53	0.73		
	Girl	292	3.48	0.80		
	Gap		-0.06		0.387	

Note: * $p < .05$.

mean score for *Aspirations in science* was $M = 3.13$ ($SD = 0.93$); that of the girls was $M = 3.07$ ($SD = 0.92$).

Note that the two 6th grade components that were significantly different by gender both dealt with peer groups. Specifically, an independent samples t-test showed that boys ($M = 3.22$, $SD = 0.78$) and girls ($M = 3.09$, $SD = 0.74$) differed significantly in their mean score on *Peer orientation to school* (t (536) = 2.082, $p = .038$), but with very small[29] effect size ($d = .18$). As well, the boy's *Peer attitudes to science* mean score ($M = 2.99$, $SD = 0.99$) was significantly different from the girls ($M = 2.80$, $SD = 0.90$), with small effect size ($d = .20$). Taken together, these results suggest that, on average, the 6th grade boys thought that their peers had a more positive attitude towards school and science in comparison to the 6th grade girls.

4.2.5 Limitations of the 6th grade instrument (with respect to this study)

One key consideration in analysing the limitations of the 6th grade survey instrument with respect to this study involves the theorized component structures of the survey items. More specifically, five of the components proposed by DeWitt et al. (2011) did not emerge in the principal components analyses of the 6th grade survey data: *Family involvement*, *Self-concept in science-negative*, and three components related to future jobs. Instead, the items theorized to form these components generally loaded onto components with no clear meaning. For example, the 11 items belonging to question stem 'Q6 More about my future job…' were theorized to produce three job-related components (Future job-ambition, Future job-social, and Future job-creating/making). In the initial principal components analysis of the survey data, however, these 11 items loaded across a range of otherwise well-defined components; consequently, the eleven items were removed from the analysis. Similarly, the eight items from question stem 'Q9 Science lessons and me…' were theorized to form both a positive and a negative version of the component *Self-concept in science*; in this analysis six of the eight Q9 items loaded onto a single component. Further complicating the analysis, several items loaded "across" question stems. For example, item 'q9f If I study hard, I will do well in

[29] Cohen (2013) suggests as a rule of thumb that effect sizes of 0.2, 0.5, and 0.8 standard deviations be classified as "small", "medium", and "large".

science' was expected to load onto the theorized *Self-concept in science-positive* component; in this analysis the item loaded on *Experience of school science*.

The 6th grade survey instrument was always intended to be utilized in an exploratory manner in this study, providing data that could provide a clearly interpretable first PCA solution. Nonetheless, based on this study's results it is thought that the questionnaire could be refined for use with groups similar to the East Los Angeles 6th grade sample. For example, based upon low alpha scores, the two components *Peer orientation to school* (.620) and *Image of scientists-negative* (.548) could be strengthened by revision of the items that compose their subscales. More specifically, the wording of several items should be reconsidered. Consider Table 4.4, which displays the percentage of sixth grade students by school attended that met or exceeded California state standards in the academic year this study was conducted (2014-2015). It can be inferred from the table that, on average, more than two out of three of these students tested as reading below or well below grade level proficiency. Consequently, given the overall level of reading proficiency among these 6th grade students, items with low primary loadings on their theorized component could be rewritten in simpler form. For example, item 'q7e (How many of your classmates) Encourage you to do well in school?', which had a primary loading of .596 on the component *Peer orientation to school*, might be rewritten '(How many of your classmates) Want you to do good in school?'.

Table 4.4. Percentage of 6th grade students meeting or exceeding California state standards in English Language Arts and Mathematics (2014-2015).

School[a]	English Language Arts[b] (%)	Mathematics[b] (%)
Halley MS	33.3	33.3
Hawking MS	21.4	13.3
Lorentz MS	25.0	21.3
Mendel MS	34.8	20.1
Tesla MS	20.8	19.3
Thompson MS	32.3	19
Average	27.9	21.1

Notes: [a]All names are pseudonyms.
[b]Data sourced from LAUSD (2017).

Another way in which the questionnaire could be refined – based on the outcomes of this study – would be to review items that had large cross loadings in this analysis. For instance, item 'q9d I understand everything in my science class' had a primary loading of .470 on *Self-concept in school science* and a secondary loading of .458 on *Experience of school science*; this item was theorized to load primarily on *Experience of school science*. Note, however, these two components were highly correlated ($r = .695$, $p < .001$), suggesting that the original conceptualization of these components could be usefully revisited.

4.2.6 Summary of the 6th grade principal components analysis

A principal components analysis of the 6th grade survey data produced a reliable ten-component solution. Further analysis of the solution showed significant differences in response patterns by gender on the components *Peer attitudes to science* and *Peer orientation to school*. Evaluating the limitations of the survey instrument with respect to the outcomes of the principal components analysis suggests some revisions in item wording and component theorization.

4.3 Principal components analysis of the 9th grade sample

This section presents the principal components analysis (PCA) of survey data gathered from the 9th grade students. Theoretical considerations of the constructs measured in the survey were discussed above, in the analysis of the 6th grade sample data. Consequently, the focus of this section is on unique aspects of the 9th grade results. This section begins by briefly reviewing the methods and assumptions of the 9th grade PCA. Then, the results of the PCA of the data are presented. Following is a concise analysis of the results with respect to the context of this study. Lastly, limitations of the instrument used to acquire the 9th grade data are detailed.

4.3.1 Method summary: Participants, Materials, and Procedure (as related to the principal components analysis) – 9th grade

Ninth grade students attending five inclusive public schools in East Los Angeles participated in this study's survey designed to explore their science aspirations. The instrument used for the 9th grade students was based on the ASPIRES questionnaire (see Appendix 1). The questionnaire was successfully completed by 428 9th grade students (14- to 15-years of age). Table 3.7 provides basic descriptive information about the survey population from each of the schools that participated. Data collection was completed as described in Section 3.8. The 9th grade data gathered was initially analysed using a principal components analysis, discussed next.

4.3.2 Data assessment and assumption testing – 9th grade

As with the 6th grade data, the 9th grade data was screened and tested for sampling adequacy and factorability. The results of the 9th grade data assessment and assumption testing are reported in Appendix 4.

4.3.3 Results of the 9th grade principal components analysis

This subsection begins by reviewing the initial principal components analysis of the 9th grade data. Next, the final PCA solution is detailed. Then, the reliability of the final solution is assessed. Lastly, component scores are presented.

4.3.3.1 Principal components analysis of the 9th grade data

A first principal components analysis of 56 survey items resulted in 14 components with eigenvalues over Kaiser's criteria of one. The first four components explained 19%, 7%, 6% and 5% respectively; the remaining components contributing less than 4% each. In combination the fourteen components explained 63.2% of the variance in the solution.

Inspection of the scree plot (Figure 4.12) of the analysis suggested solutions of three, eleven, and fourteen components. Consequently, solutions with three, eleven, and fourteen components were examined using orthogonal (varimax) and oblique (oblimin) rotations of the factor loading matrix. The eleven-component solution, which explained 57% of the variance, was chosen because of (1) clear previous theoretical support of the components, (2) the inflection point at eleven on the scree diagram with subsequent levelling off of remaining eigenvalues, and (3) the insufficient number of primary loadings (two or fewer items) on the remaining components (components 11-14). There was little discernible difference in the initial eleven component varimax and oblimin solutions.

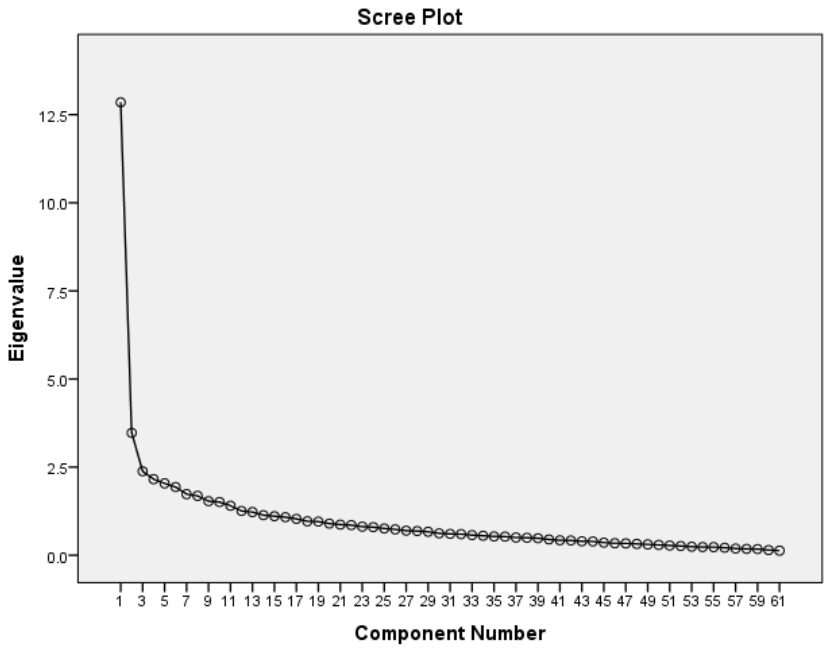

Figure 4.12. Scree plot of initial 9th grade PCA (SPSS 22 output).

The choice of an eleven-component solution resulted in ten items being removed from the analysis. Four items were dropped because they did not contribute to a clear component structure. They were ‘q2a Go to a museum’, ‘q2e Visit a science center, science museum or zoo’, ‘q5d They know how well I am doing in school’, and ‘q11a Most girls/boys like the same kinds of things that I do’. One item, ‘q9f If I study hard I will do well in science’, did not meet the criteria of having a primary factor loading of .4 on any component. Of the six items that dealt with future careers, only the item ‘q6b work in science’ loaded onto an already clearly structured and well-defined component (*Aspirations in science*). Rather than complicate the analysis, all six questions dealing with the future jobs question stem were subsequently excluded from the principal components analysis of the 9th grade data. Once it was determined which items were to be included, a final principal components analysis was carried out.

4.3.3.2 Final principal components analysis solution

A principal components analysis of the remaining 46 items was conducted, using both varimax and oblimin rotations. The varimax rotation producing orthogonal components was preferred for providing a clear component structure and interpretation (Tabachnick & Fidell, 2013). The first eleven components explained 54.8% of the variance. A twelfth component was composed of a single item, ‘q14e (Scientists…) are weird’ with a loading of .634. However, as it was the only item loading on the twelfth component, and as it had a secondary loading of .332 on its theorized question stem (negative stereotype of scientists), the item was located together with items ‘q14g spend most of their time working alone’ and ‘q14h don’t have many interests in life’.

As with the 6th grade analysis, the component structures generally mapped onto those proposed by DeWitt et al. (2011), albeit with some differences (discussed below). Components with similar structures as those theorized and named by DeWitt et al. (2011) were assigned the same label in this study. Those components are:

- *Aspirations in science*
- *Experience of school science*
- *Family ambitions*

- *Family attitudes to science*
- *Family involvement*
- *Image of scientists-negative*
- *Image of scientists-positive*
- *Outside of school science*
- *Peer attitudes to science*
- *Peer orientation to school*
- *Self-concept in science*

The factor loading matrix for the final solution is presented in Table 4.5. Components are displayed in order of percent variance accounted for by the component in the solution. For example*, Aspirations in science,* explaining 6.58% of the variance, is the third component listed. The four items loading on this component consisted of items measuring a students' desire to continue studying science and have a career as a scientist in the future. The item with the largest loading (.821) on this component was 'q11d I would like to become a scientist'; the smallest loading (.526) was item 'q11b I would like to study more science in the future.

Note that four items had cross loadings of .4 or above. For example, item 'q5g They always attend parent conferences at school' had a primary loading of .493 on *Family involvement* and secondary loading of .446 on *Family attitudes to science.* However, the cross loadings did not impact the reliability of the PCA, as demonstrated by the reliability analysis for the eleven principal components solution, presented next.

Table 4.5. 9th grade factor loadings, communalities, and percentage of variance of principal components extraction with varimax rotation.

Item	C_1[a]	C_2[a]	C_3[a]	C_4[a]	C_5[a]	C_6[a]	C_7[a]	C_8[a]	C_9[a]	C_{10}[a]	C_{11}[a]
q8d I look forward to my science class.	.757										
q8e Science class is exciting.	.735										
q8c We learn interesting things in science class.	.719										
q8a My teacher expects me to do well in science.	.527										
q8f Studying science is useful for getting a good job…	.492										
q9a I find science difficult. (Reverse coded).		.807									
q9b I am not good at science. (Reverse coded).		.693									
q9c I learn things quickly in science class.		.612									
q9d I understand everything in my science class.		.582									
q9e Science is one of my best subjects.		.519									
q9g I feel lost in science class. (Reverse coded).		.473									
q9f If I study hard, I will do well in science.		.384									
q11d I would like to become a scientist.			.821								
q11e I think I could be a good scientist one day.			.748								
q11c I would like to have a job that uses science.			.745								
q11b I would like to study more science in the future.			.526								
q5e They want me to get a good job when I grow up.				.815							
q5b It is important to them that I try my best in school.				.717							
q5a It is important to them that I get good grades in school.				.695							
q5f They want me to make a lot of money when I grow up.				.687							
q5c They expect me to go to college.				.678							
q14a can make a difference in the world.					.699						
q14b make a lot of money.					.696						
q14d are smart.					.677						
q14c have exciting jobs.					.647						
q14f are respected by people.					.613						
q2c Read a book or magazine about science.						.760					
q2d Visit web sites about science.						.746					
q2f Watch a TV programme about science or nature.						.648					
q2b Do science activities.						.616					
q2g Talk with someone at home…						.435					
q8b I get good grades in science.							.697				
q5d They know how well I am doing in school.							.632				
q9h I do well in science.		.427					.620				
q5g They always attend parent conferences at school.							.493	.446			
q5i My family think it is important for me to learn science.								.744			
q5h My family think science is interesting.								.701			
q5j My family would be happy if I became a scientist…			.438					.468			
q7d Care about their grades in school?									.784		
q7f Are smart?									.715		
q7e Encourage you to do well in school?									.706		
q7a Like science?										.775	
q7b Think science is cool?										.689	
q7c Get good grades in science?									.456	.488	
q14h don't have many other interests in life.											.785
q14g spend most of their time working alone.											.706
q14e are weird.											.332
	C_1[a]	C_2[a]	C_3[a]	C_4[a]	C_5[a]	C_6[a]	C_7[a]	C_8[a]	C_9[a]	C_{10}[a]	C_{11}[a]	h^2
Eigenvalues	3.28	3.24	3.09	2.96	2.90	2.60	2.23	2.08	2.05	1.88	1.77	
% of variance	6.99	6.89	6.58	6.29	6.17	5.53	4.75	4.43	4.36	4.01	3.77	59.76
Cronbach's α	.820	.807	.830	.717	.755	.714	.723	.729	.658	.636	.520	

[a]Component label:
- C_1 - *Experience of school science*
- C_2 - *Self-concept in science*
- C_3 - *Aspirations in science*
- C_4 - *Family ambitions*
- C_5 - *Image of scientists-positive*
- C_6 - *Outside of school science*
- C_7 - *Family involvement*
- C_8 - *Family attitudes to science*
- C_9 - *Peer orientation to school*
- C_{10} - *Peer attitudes to science*
- C_{11} - *Image of scientists-negative*

4.3.3.3 Reliability analyses

The internal consistency of the subscales that emerged from the principal components analysis were assessed using Cronbach's alpha (α), shown at the bottom of Table 4.5. The majority of the alphas were above or quite close to the generally accepted minimum of .7 (Field, 2013, p. 675) with one exception: *Image of scientists (negative)* had an alpha of .520. However, and as noted in the 6th grade PCA above, it is not unexpected for attitudinal scales with relatively few items to have low alphas, especially with children. Consequently, given that the items mapped very well onto the theorized construct, the component was retained.

Each component was checked to see if dropping any item would improve reliability. There was no appreciable change in the alpha of any component if any their constituent items were removed. Once the solution obtained from the principal components analysis was determined to be reliable, composite scores for the extracted components were created.

4.3.3.4 Component scores

Component scores were generated by finding the mean score for the items that loaded primarily on a component (see Section 4.2 for details). Item scores ranged from 1 (strongly disagree) to 5 (strongly agree); accordingly, component scores similarly ranged from 1 to 5. Higher scores indicate a more positive attitude or belief, with scoring reversed in the analysis for negatively worded items (e.g., 'I am not good at science'). Complete descriptive statistics of the component scores are presented in Table 4.6. For example, *Aspirations in science*, had a mean score of 2.84 (*SD* = 0.77).

The normality of distributions with samples larger than 300 are usually assessed by examination of the shape of the distributions. Careful inspection of component score histograms (see Appendix 4) showed approximate normal distributions, with the exception of *Family ambitions*. More specifically, *Family ambitions* had a highly negatively skewed and leptokurtic distribution; as a result, the component was dichotomized for use in the regression analysis (detailed in Chapter 5).

Table 4.6. 9th grade component scores and descriptive statistics.

Component	*Mean*	*SD*	*Range*	*Skewness (z score)*	*Kurtosis (z score)*	*N*
Aspirations in science	2.84	0.77	1-5	1.06	1.95	427
Experience of school science	3.91	0.65	1-5	-5.72	1.58	427
Family ambitions[a]	4.66	0.52	1-5	-16.63	23.89	427
Family attitudes to science	3.38	0.75	1-5	-0.38	2.32	424
Family involvement	3.79	0.74	1-5	-6.02	1.71	426
Image of scientists-negative	2.94	0.71	1-5	0.81	1.55	426
Image of scientists-positive	4.09	0.57	1-5	-4.26	2.32	426
Outside of school science	2.27	0.82	1-5	2.76	-2.45	427
Peer attitudes to science	2.93	0.62	1-5	-0.10	5.37	422
Peer orientation to school	3.14	0.79	1-5	0.92	-0.80	423
Self-concept in science	3.29	0.67	1-5	0.25	2.23	426

Note: [a]*Family ambitions* was dichotomized for use in the multiple regression analysis.

4.3.4 Analysis of the 9th grade principal components analysis

The results of the PCA of the 9th grade data are analysed here. First the final eleven component solution is reviewed. Then the mapping of items onto theorized concepts is examined. Lastly, differences on the component scores by gender are explored.

4.3.4.1 Eleven-component structure of the 9th grade solution

A principal components analysis with varimax orthogonal rotation revealed an eleven-component structure for 46 survey items. Ten of the eleven components that emerged mapped clearly onto previously theorized constructs and each component was found to be internally consistent. The original set of items was accordingly restructured into one component representing science aspirations and ten components theorized to influence science aspirations.

4.3.4.2 Mapping of items onto components

As the general characteristics of the components were previously examined in the analysis of the 6th grade PCA (Section 4.2), and to avoid needlessly repetitive analysis, only the five

components that emerged as significant predictors of *Aspirations in science* in the regression analysis (Chapter 5) are included here. Consequently, analysis of the 9th grade components *Family ambitions*, *Family involvement*, *Image of scientists-positive*, *Image of scientists-negative*, and *Peer orientation to school* are located in Appendix 4.

4.3.4.2.1 *Family attitudes to science* – 9th

The items that comprised this component were: How much do you agree with these statements about your family…

- q5h My family think science is interesting.
- q5i My family think it is important for me to learn science.
- q5j My family would be happy if I became a scientist when I grow up.

Figure 4.13 shows item scores by percentage, with the percentage of the combined categories of 'agree' and 'strongly agree' displayed to the right of the 'neither' bar. The overall response pattern for this component was not particularly positive. For instance, just one in three 9th grade students (34.8%) thought that their parents would be happy if they chose a career in science (q5j). Similarly, only 38.5% of students agreed or strongly agreed that their family thought science was interesting (q5h). The low on-average attitudinal response pattern for the items that make up *Family attitudes to science* is notable in light of the influence family

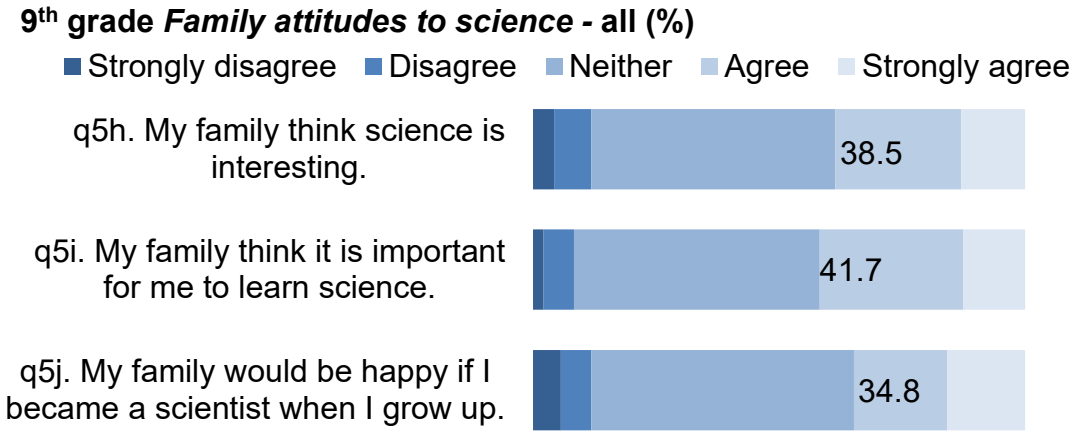

Figure 4.13. Item responses for the 9th grade component *Family attitudes to science*.

science attitudes have been theorized to have on science aspirations (e.g., Archer et al., 2012).

4.3.4.2.2 *Peer attitudes to science* – 9th

The items that made up this component were: How many of your classmates…

- q7a Like science?
- q7b Think science is cool?
- q7c Get good grades in science?

Figure 4.14 displays item scores by percentage, with the percentage displayed in the bars corresponding to the combined categories of 'nearly all' to 'all'. Most of these 9th grade students did not think that the majority of their classmates held positive views of science, with 'some' the largest response category for all three items. For example, fewer than one in four (24.5%) thought that all or nearly all of their fellow students liked science (q7a). Interestingly, the 9th grade students' evaluations of their peers' attitudes towards science is noticeably different from their own positive science-related views, as reported next in the analysis of *Experience of school science*.

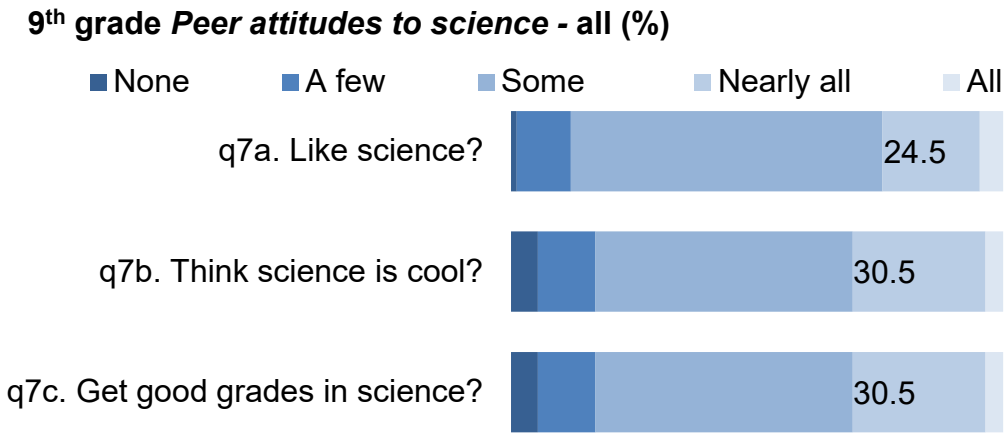

Figure 4.14. Item responses for the 9th grade component *Peer attitudes to science*.

4.3.4.2.3 *Experience of school science* – 9th

The set of items dealing with students' experience of school science were: How much do you agree with these statements…

- q8a My teacher expects me to do well in science.
- q8c We learn interesting things in science class.
- q8d I look forward to my science class.
- q8e Science class is exciting.
- q8f Studying science is useful for getting a good job in the future.

Figure 14.15 displays item scores by percentage, with the percentage of the combined categories of "agree" and "strongly agree" displayed. The results for this set of items were very positive. For example, over two-thirds (68.7%) of 9th grade students agreed or strongly agreed that they looked forward to their science class (q8d), compared with only about 10% disagreeing or strongly disagreeing with this statement. As well, a sizable majority of the students (84.2%) agreed or strongly agreed that they learned interesting things in science

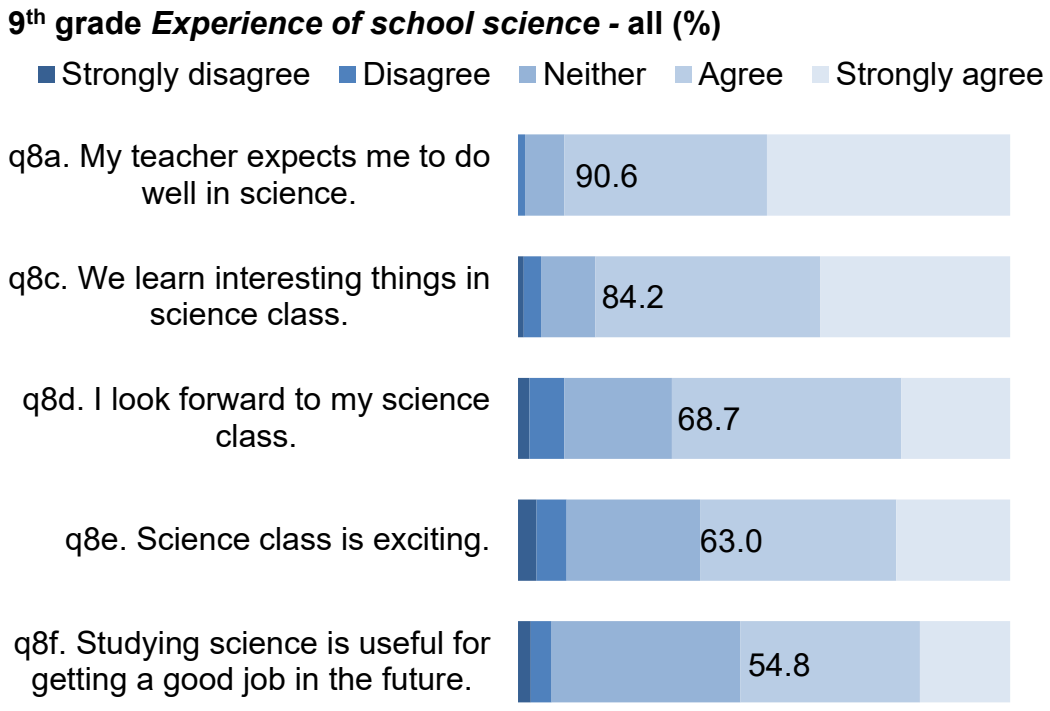

Figure 4.15. Item responses for the 9th grade component *Experience of school science*.

(q8c). The overall positive attitudes towards school science is notable because student's experience of school science was theorized to be linked to these students' science self-concept, the next component analysed.

4.3.4.2.4 *Self-concept in science* – 9th

The six items that made up this component were: How much do you agree with these statements…

- q9a I find science difficult.
- q9b I am not good at science.
- q9c I learn things quickly in science class
- q9d I understand everything in my science class
- q9e Science is one of my best subjects.
- q9g I feel lost in science class.

Figure 4.16 displays item scores by percentage, with the percentage of the combined

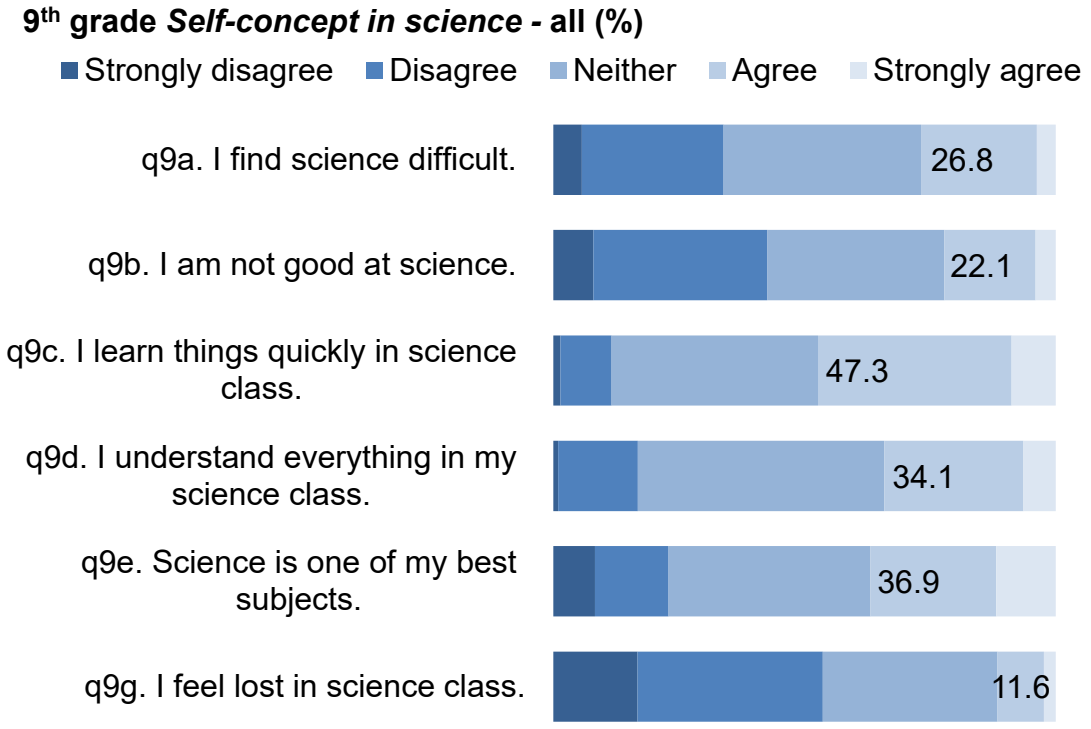

Figure 4.16. Item responses for the 9th grade component *Self-concept in science*.

categories of ‘agree’ and ‘strongly agree’ shown. The items in this component were originally theorized to produce both a positive and negative self-concept component; however, the items loaded onto a single component. The majority response on most items was the neutral ‘neither agree nor disagree’, with about one-third of the 9th grade students expressing positive responses to the self-concept in science items. For instance, for item ‘q9d I understand everything in my science class’ nearly half (49.1%) of the students neither agreed nor disagreed, with just 34.1% agreeing or strongly agreeing with the statement. Item q9c differed slightly from the ‘neither…’ majority trend: nearly half the students (47.3%) agreed that they learned things quickly in science class, whereas only one in ten (11.6%) disagreed.

While overall these students did not have especially *positive* science self-concepts, examination of the three reverse phrased items suggests that neither do they have a *negative* self-concept in science. For example, only about one in four (26.8%) agreed with the reverse phrased item ‘q9a I find science difficult’. As well, just one in ten students (11.6%) agreed that they felt lost in science class (q9g).

4.3.4.2.5 *Outside of school science* – 9th

The five items that constituted this component were: How often do you do the following things when you are NOT in school…

- q2b Do science activities (e.g., science kits, nature walks, do experiments).
- q2c Read a book or magazine about science.
- q2d Visit websites about science.
- q2f Watch a TV program about science or nature.
- q2g Talk with someone at home about what I’ve been learning in school.

Figure 4.17 displays item scores by percentage, with the percentage of the category ‘never’ displayed. Responses to the first three items suggest most of these 9th grade students had little, if any, interaction with science outside of school. For instance, the response pattern to item q2c indicates that nearly half of all these 9th grade students (46.1%) did not read science related material outside school. Further evidence of low interaction with science outside of school can be seen within the response pattern to item q2d, with 38.8% of the students never

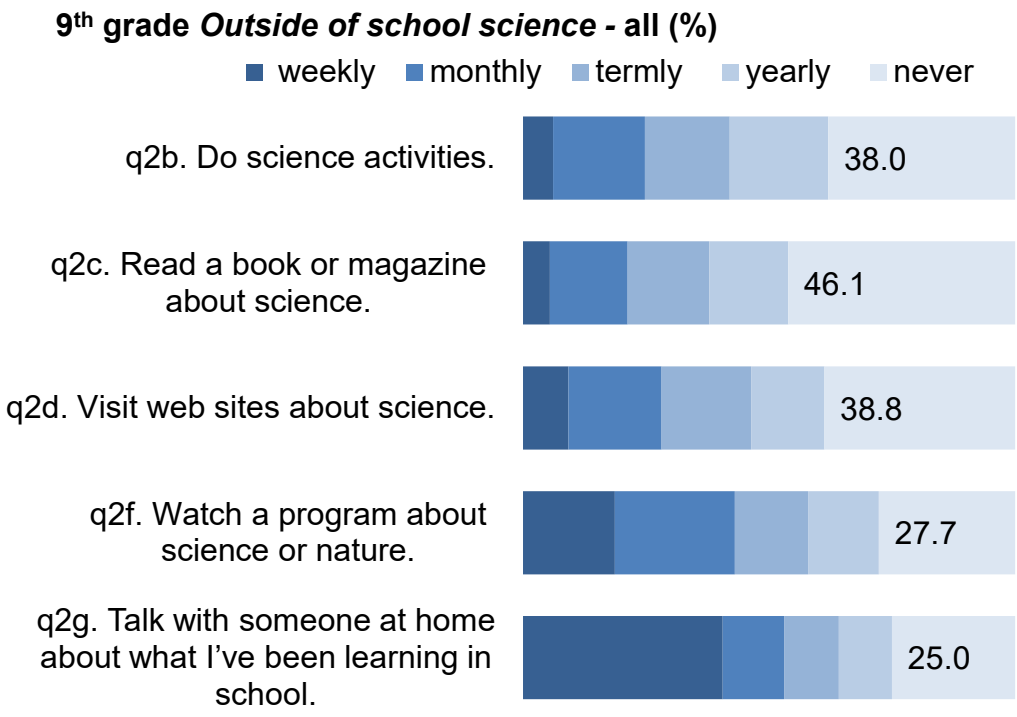

Figure 4.17. Item responses for the 9th grade component *Outside of school science*.

using science websites and just one in four (28.1%) visiting websites to do with science once a month or more.

The remaining two items have somewhat different response patterns. Specifically, only one in four students (27.7%) responded that they never watch TV shows about science or nature (q2f); on the other hand, 43% of students reported that they a watch a science related TV program at least once a month. With respect to item 'q2g Talk with someone at home about what I've been learning in school', it is worth noting that the item was expected to load onto the *Family involvement* component. Unsurprisingly, the response pattern on this item aligns well with the pattern of positive responses found for *Family involvement* (see Appendix 4): just one in four students (25.0%) reported that they never talk to family about school, while more than half (53.1%) do so at least once a month.

As with the 6th grade sample, additional understanding into the response patterns for *Outside of school science* is gained by considering the response pattern to item 'q2e Visit a science center, science museum or zoo'[30]. Specifically, the student responses to item q2e indicate that half of the 9th grade students (49.4%) never go to museums or science centres – not surprising given the socioeconomic profile of East Los Angeles (see Section 1.3).

4.3.4.2.6 *Aspirations in science* – 9th

The dependent variable of this study, *Aspirations in science,* was made up of four items: How much do you agree with these statements…

- q11b I would like to study more science in the future.
- q11c I would like to have a job that uses science.
- q11d I would like to become a scientist.
- q11e I think I could be a good scientist one day.

Figure 4.18 displays item scores by percentage, with the percentage of the combined categories 'agree' and 'strongly agree' given to the right of the 'neither' band. Overall, most students did not agree with any of these items, suggesting low overall science aspirations as a group. For example, just one out of four 9th grade students (25.6%) agreed or strongly agreed with item 'q11c I would like to have a job that uses science'. In fact, more students *strongly* disagreed (13.9%) with item 'q11d I would like to be a scientist' than the combined students who agreed or strongly agreed (11.7%). The lack of interest in becoming a scientist reported by these students aligns with the response pattern for item q11e: very few (17.1%) of the students see themselves as potentially being good scientists.

Note that the agree/strongly agree response rate (39.9%) on item 'q11b I would like to study more science in the future' is rather large in comparison to the other three items that made up the *Aspirations in science* measure. Consequently, a repeated measures ANOVA was conducted in order to determine whether mean responses on the items that composed the

[30] This item was theorized to load onto *Outside of school science*. It was not included in the final solution due to low primary loading values.

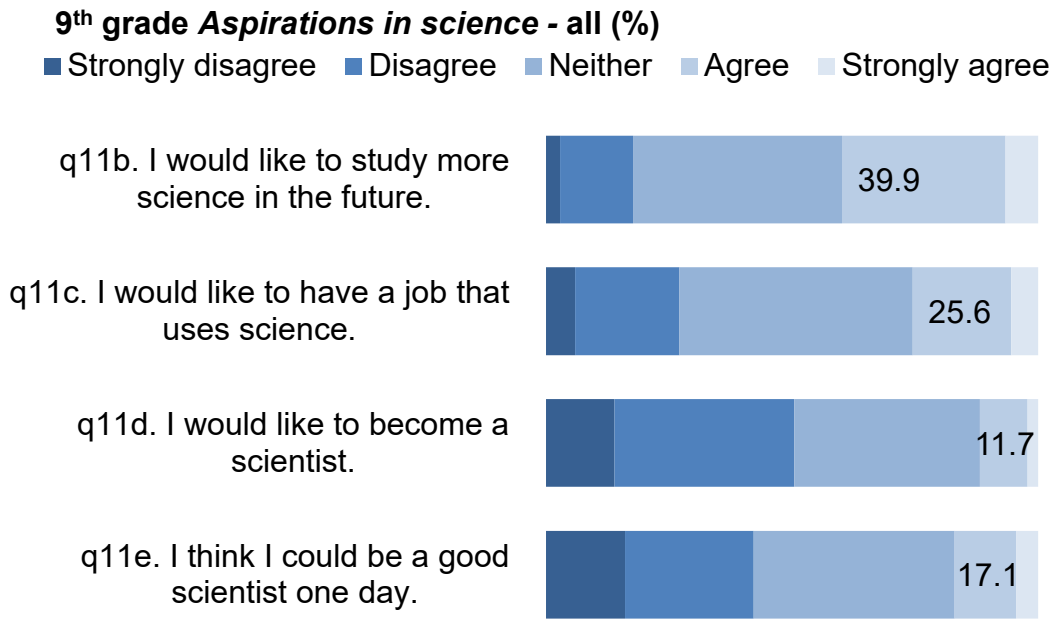

Figure 4.18. Item responses for the 9th grade component *Aspirations in science*.

Aspirations in science component were significantly different from one another[31]. The results show that mean responses on the items were significantly different, F (2.618, 1104.822) = 123.472, $p < 0.001$, $\eta^2 = .226$. Post hoc tests using the Bonferroni correction revealed that the mean of item 'q11b I would like to study more science in the future' ($M_{q11b} = 3.26$, $SD_{q11b} = 0.90$) was significantly different ($p < .001$) from the other items that comprised the *Aspirations in science* component ($M_{q11c} = 2.98$, $SD_{q11c} = 0.92$; $M_{q11d} = 2.50$, $SD_{q11d} = 0.92$; $M_{q11e} = 2.64$, $SD_{q11e} = 1.030$).

In order to gain further understanding into these 9th grade students' science aspirations it is useful next to examine scores on *Aspirations in science* and other components by different student characteristics. To begin, comparisons were carried out by gender.

[31] As Mauchly's test indicated that the assumption of sphericity had been violated, $\chi^2 = 90.547$, $p < .001$, Greenhouse-Geiser corrected tests are reported here ($\varepsilon = .873$).

4.3.4.3 Gender differences on component score means – 9th grade

Table 4.7 displays mean scores on the 9th grade components by gender and shows five significant gender differences within the eleven components. The most significant gap was on the component *Family ambitions*, with an independent samples t-test (t (422) = 3.403, p = .001) indicating that girls (M = 4.74, SD = 0.37) held a significantly higher mean than boys (M = 4.59, SD = 0.52), with small effect size (d = .34). Although not significant, girls (M = 3.82, SD = 0.71) also held a slightly higher mean than boys (M = 3.74, SD = 0.77) on the component *Family involvement*. Taken together, these two component score gaps suggest stronger family influence on these 9th grade girls, with respect to school and how it shapes their future, in comparison to the 9th grade boys.

On the other hand, boys held higher means on the remaining four significantly different component means. For example, the largest gap between boys and girls was on the component *Outside of school science*, although both scores are quite low (recall that a score of '2' corresponds to yearly, while '3' corresponds to termly). The 9th grade boy's mean (M = 2.39, SD = 0.85) was significantly higher (t (422) = 2.674, p = .008) than the 9th grade girl's mean (M = 2.18, SD = 0.79), with small effect (d = .26). As well, the 9th grade boys held a significantly higher mean on component *Peer attitudes to science*, with an independent samples t-test (t (418) = 2.445, p = .015) showing that the boys (M = 3.01, SD = 0.64) and girls (M = 2.86, SD = 0.59) significantly differed, also with small effect size (d = .24). Lastly, the 9th grade boys held a significantly higher mean on the dependent variable of this study, *Aspirations in science*. An independent samples t-test (t (423) = 2.282, p = .023) indicated that the boys (M = 2.93, SD = 0.82) and girls (M = 2.76, SD = 0.73) had significantly different scores, with small effect size (d = .22). Taken together, these results suggest a gender gap for science aspirations and some science-related attitudes, although with the caveat that both genders can be considered to have had rather low science aspirations.

Table 4.7. 9th grade component score means by gender.

Component	*Gender*	*Count*	*Mean*	*SD*	*p*	*Cohen's d*
Aspirations in science	Boy	197	2.93	0.82		
	Girl	228	2.76	0.73		
	Gap		**-0.17***		**0.023**	**0.22**
Experience of school science	Boy	197	3.89	0.69		
	Girl	228	3.93	0.62		
	Gap		0.04		0.586	
Family ambitions	Boy	196	4.59	0.52		
	Girl	228	4.74	0.37		
	Gap		**0.15****		**0.001**	**0.34**
Family attitudes to science	Boy	197	3.40	0.81		
	Girls	225	3.35	0.70		
	Gap		-0.05		0.496	
Family involvement	Boy	197	3.74	0.77		
	Girls	227	3.82	0.71		
	Gap		0.08		0.255	
Image of scientists-negative	Boy	197	3.03	0.71		
	Girl	227	2.86	0.71		
	Gap		**-0.17***		**0.021**	**0.23**
Image of scientists-positive	Boy	197	4.06	0.62		
	Girl	227	4.11	0.52		
	Gap		0.05		0.355	
Outside of school science	Boy	197	2.39	0.85		
	Girl	228	2.18	0.79		
	Gap		**-0.21****		**0.008**	**0.26**
Peer attitudes to science	Boy	194	3.01	0.64		
	Girl	226	2.86	0.59		
	Gap		**-0.15***		**0.015**	**0.24**
Peer orientation to school	Boy	195	3.15	0.78		
	Girl	226	3.14	0.80		
	Gap		-0.01		0.832	
Self-concept in science	Boy	197	3.34	0.70		
	Girl	227	3.24	0.64		
	Gap		-0.10		0.145	

Note: * $p < .05$, ** $p < .01$.

4.3.5 Limitations of the 9th grade instrument (with respect to this study)

As with the 6th grade sample, the theorized component structures did not match the empirically determined structures for the 9th grade sample. Consequently, the results of this analysis suggest that the theorized component structures are not invariant across populations. This outcome will be examined further in Chapter 6 (Sample Comparisons and Contrasts).

4.3.6 Summary of the 9th grade principal components analysis

A principal components analysis of the 9th grade sample data was found to have a reliable eleven-component solution and with several significant differences in response patterns by gender, including *Aspirations in science*. The ten components theorized to predict *Aspirations in science* were generated for use in a multiple regression analysis (Chapter 5), together with several measures of student background characteristics which are explicated next.

4.4 Student background measures

This section details how data collected from both survey questionnaires were employed to generate five background measures for use in the analysis of these East Los Angeles students' science aspirations. Three of the measures have been previously associated with science aspirations: student ethnicity, gender, and socioeconomic status (e.g., Aschbacher et al., 2010, 2014; Bennett & Hogarth, 2009; Dabney et al., 2012; DeWitt et al., 2011, 2013, 2014; Gilmartin et al., 2006). Previous research has also shown that academic outcomes for Latino children are associated with home language use (e.g., Eamon, 2005; García-Vázquez et al., 1997; Lee, 2005). A student's generation of immigration, very pertinent to the context of East Los Angeles, has been linked to aspirations, achievement, and attainment (e.g., Tienda, 2009; Portes & MacLeod, 1996). These five background variables, generated identically for both the 6th and 9th grade samples, are described below.

4.4.1 Ethnic group

Information on students' ethnic group was collected through self-identification from seven ethnic categories. The seven categories were: White; Black or African American; Latino (Mexican, Mexican American, or Chicano); Latino (other); Asian; American Indian or Alaska

Native; and Native Hawaiian or other Pacific Islander. Latinos accounted for 94.4% of the 6th grade sample (N = 539) and 90.9 % of the 9th grade sample (N = 428). For the 6th grade data there were no missing cases, while for the 9th grade sample there were two missing cases and they were placed with 33 non-Latino students in the category 'Other'.

4.4.2 Gender

The 6th grade sample consisted of 245 boys and 294 girls, while there were 200 boys and 228 girls included in the 9th grade sample. There were no cases of missing data. For use in the regression analysis this variable was dummy coded, with boys as the reference group (boys were coded 0 and girls were coded 1).

4.4.3 Generation of immigration

Generation of immigration was of interest to this study due to the position East Los Angeles occupies as a Latino gateway community. More specifically, it was hypothesized that an inverse relation between aspirations in science and generation of immigration exists in East Los Angeles. That is to say, second-generation students were theorized to have lower science aspirations than first-generation students. Differences in science aspirations are seen in light of the ideas of segmented assimilation (Portes & Zhou, 1993), where certain groups in the U.S. (i.e., Latinos) get stopped in their assimilation to middle-class economic status. Thus, in this study it is thought that if an immigrant family initially settles into East Los Angeles and remains through their children's school years, their children will internalize the neighbourhood attitudes and aspirations.

Table 4.8 displays the percentage of each sample by generation of immigration, with 2nd generation by far the largest category for both the 6th grade (68.6%) and 9th grade (58.2%) samples. Information on the generation of immigration was collected through student self-identification from four categories. The choices were: 'I was born here', 'One or both of my parents were born here', 'One or more of my grandparents were born here', and 'I was born in another country'. These responses were coded into four categories: first-generation, second-generation, third-generation, and fourth-generation. If a student marked more than one response the generation was coded with the "oldest" generation. The 6th grade sample had four

Table 4.8. Percentage of samples by generation of immigration.

Generation of immigration	6th (%)	9th (%)
1st	5.2	7.0
2nd	68.6	58.2
3rd	18.2	22.2
4th	7.2	9.8
Total	535	416

Note: Columns do not sum to zero.

cases of missing data, while the 9th grade sample had twelve cases of missing data, both of which were which were imputed with the mode.

4.4.4 Home language use

Table 4.9 displays the percentage of each sample on this variable. Note that the largest category is the use of a home language other than English 'All or most of the time' for both the 6th grade (59.4%) and 9th grade (54.4%) sample. Information on language use at home was collected by student responses to the item 'How often do people in your home talk to each other in a language other than English?': 'Never', 'Once in a while', 'About half of the time', and 'All or most of the time'. The 6th grade sample had ten cases of missing data and the 9th grade sample had nine, both which were imputed with the mode.

Table 4.9. Percentage of samples by home language use other than English.

Home language use	6th (%)	9th (%)
Never	5.9	4.9
Once in a while	12.1	11.9
About half the time	20.8	26.6
All or most of the time	59.4	54.4
Total	529	419

Note: Columns do not sum to zero.

4.4.5 Socioeconomic status

A socioeconomic status (SES) index was generated for this study, providing a measure of relative SES in an extremely economically marginalized area: the persons in poverty percentage in East LA is 26.9 %, nearly twice the official U.S. poverty rate of 14.8 % (U.S. Census Bureau, 2015). While the use of some common indicators of socioeconomic status such as free lunch (e.g., Strand, 2014a, 2014b) were considered, they could not differentiate individuals in East Los Angeles. For example, Table 3.1 shows that the average percentage of middle school students eligible to receive free lunch was above 90% for the East Los Angeles schools that participated in this study. Another widely used indicator, neighbourhood deprivation index (e.g., Strand, 2014a), was not included for the same reason: over 90% of participants fall within the same category. The use of yet another frequently used indicator of SES, the socioeconomic classification of the home (SEC) (e.g., Strand, 2014a; Sirin, 2005), was complicated by the difficulty many students in this study had identifying their parents' occupations.

Consequently, in order to generate a SES measure from available indicators, a categorical principal components analysis (CatPCA) was carried out and is detailed fully in Appendix 5. Once a single composite measure of socioeconomic status was extracted from survey items, a banded SES variable consisting of five quintiles was created. Table 4.10 displays each quintile

Table 4.10. Percentage of samples by socioeconomic quintile.

SES quintile	6th (%)	9th (%)
Quintile 1	18.6	21.5
Quintile 2	21.3	19.2
Quintile 3	20.0	19.4
Quintile 4	19.5	20.1
Quintile 5	20.6	19.9
Total	539	428

Note: Columns do not sum to zero.

as a percentage of both the 6th and 9th grade samples. The classification of the students into quintiles provided the opportunity, for example, to explore response patterns on the items that constitute *Aspirations in science* by socioeconomic status and that analysis is presented next.

4.5 *Aspirations in science*: comparisons and correlations

Associations between *Aspirations in science* and student background characteristics theorized to be related to science aspirations – the focus of the third research question of this study – are examined here. Both the 6th and 9th grade *Aspirations in science* components are analyzed by gender, generation of immigration, home language use, socioeconomic status, and school attended[32]. Specifically, t-tests and one-way ANOVAs were conducted, where the null hypothesis (H_0) was equality in all population means, while the alternative hypothesis (H_1) was the difference in at least one mean. As well, correlations between *Aspirations in science* and independent variables used in the regression analysis (chapter 5) are examined for both the 6th and 9th grade samples.

4.5.1 6th grade comparisons by group – Aspirations in science

4.5.1.1 Gender

Table 4.11 displays group means for the 6th grade *Aspirations in science* component. Note that the mean aspirations scores for the boys (M = 3.13, SD = 0.93) and the girls (M = 3.07, SD = 0.92) are both below 4.00 – the value which can be considered the threshold for holding science aspirations[33]. Comparing the scores reveals a small gap (ΔM = 0.06) by gender: the boys (M = 3.13, SD = 0.93) indicated slightly higher science aspirations than girls (M = 3.07, SD = 0.92), although an independent samples t-test indicated that this difference was not significant (p = .426). Nevertheless, it is useful to examine response patterns for the items that make up this composite and, in this way, gain greater clarity into 6th grade gender differences in science aspirations.

[32] As the sample was overwhelmingly Latino (> 90%) comparisons by ethnicity were not examined.
[33] A response of '3' corresponds to 'neither agree nor disagree', while '4' corresponds to agree.

Table 4.11. 6th grade group means for *Aspirations in science* (Scale 1 to 5).

Variable and value	*N*	*Mean*	*SD*	*Cohen's d*
Gender	*537*			
Boy	245	3.13	0.93	
Girl	292	3.07	0.92	
Gap		-0.06		
Generation of immigration	*533*			
1st	28	3.12	0.79	
2nd	368	3.14	0.91	
3rd	98	2.92	1.02	
4th	39	3.18	0.93	
Gap (1st vs. 4th)		0.06		
Home language use	*527*			
Never	31	2.88	0.93	
Once in a while	65	3.04	1.05	
About half of the time	112	3.01	0.87	
All or most of the time	319	3.14	0.90	
Gap (Never vs. All)		0.26		
SES	*537*			
Quintile 1 (lowest 20%)	100	3.09	0.80	
Quintile 2	115	3.10	0.92	
Quintile 3	107	3.19	1.01	
Quintile 4	105	3.15	0.92	
Quintile 5 (highest 20%)	110	2.96	0.95	
Gap (Q1 vs. Q5)		-0.13		
School	*537*			
Halley MS	97	3.18	0.88	
Hawking MS	116	3.17	0.88	
Lorentz MS	62	2.99	0.89	
Mendel MS	86	3.44	0.86	
Tesla MS	89	2.99	0.97	
Thompson MS	87	2.77	0.95	
Gap (high vs. low)		0.67*		0.75
Grand	537	3.10	0.92	

Note: * $p < .05$.

Figure 4.19 shows item scores by percentage for the items that comprise *Aspirations in science*, with the percentage of the combined categories of 'agree' and 'strongly agree' displayed within the 'agree' band. Note that the response patterns on items q10c and q10d are quite similar with respect to gender, suggesting both boys and girls are similarly distributed with respect to their ideas about a career involving science. For example, the same percentage of boys and girls (17.1%) agreed or strongly agreed that they would like to become scientists (q10d), or less than one in five.

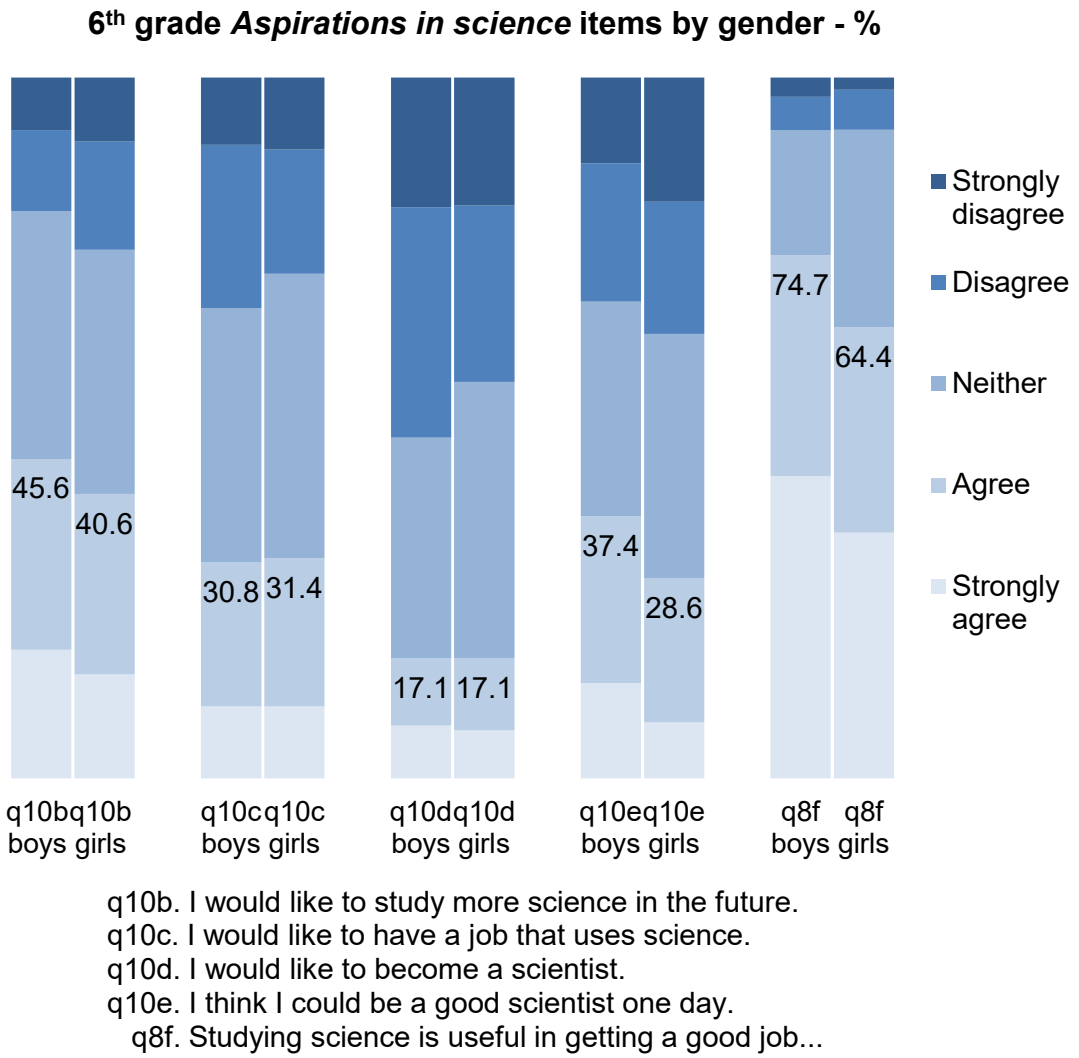

Figure 4.19. 6th grade item responses by gender for *Aspirations in science*.

On the other hand, boys and girls differ in their views about the value of studying science. In particular, there is more than a 10% difference between the boys (74.7 %) and girls (64.4 %) in the combined category of 'agree and strongly agree' for item 'q8f Studying science is useful for getting a good job in the future'. Similarly, more boys (45.6%) agreed or strongly agreed with item 'q10b I would like to study more science in the future' compared to the girls (40.6%). Taken together, the item response patterns on the *Aspirations in science* component suggest that while most of these 6th grade students do not aspire to a career in science, boys think that studying science is useful to their future plans more so than girls.

4.5.1.2 Generation of immigration

The mean scores by generation of immigration on *Aspirations in science* were similar: all were below the 'agree' threshold ($M = 4.00$), with fourth generation students holding the highest mean scores ($M = 3.18$, $SD = 0.93$) and third-generation students the lowest ($M = 2.92$, $SD = 1.02$). A one-way ANOVA showed no significant group differences by generation of immigration on the component *Aspirations in science* (F (3, 529) = 1.642, $p = .179$).

4.5.1.3 Home language use

The four group means on *Aspirations in science* by home use of another language were below the 'agree' value ($M = 4.00$). Students who used another language at home 'all the time' had the highest mean ($M = 3.14$, $SD = 0.90$) and those students who 'never' spoke another language at home had the lowest score ($M = 2.88$, $SD = 0.93$), a gap of 0.26. While it is interesting to note the decreasing magnitude of the means from 'All the time' to 'Never', a one-way ANOVA indicated there were no significant group differences by home language (F (3, 523) = 1.149, $p = .329$).

4.5.1.4 Socioeconomic status

The gap in scores between the highest SES quintile (M = 2.96, SD = 0.95) and lowest quintile (M = 3.09, SD = 0.80) was - 0.13, the opposite of the expected outcome for this measure[34]. There were no group differences by socioeconomic status (F (4, 532) = 0.955, p = .432).

4.5.1.5 School attended

There was notable variability in *Aspirations in science* mean scores when examined by school attended. Students at Mendel Middle School had the highest mean score (M = 3.44, SD = 0.86) and those at Thompson Middle School held the low score (M = 2.77, SD = 0.95), a 0.67 gap. To determine if there were significant differences between schools a one-way ANOVA was conducted, with significant result (F (5, 531) = 4.559, p < .001). Post hoc Bonferroni procedure[35] showed that Mendel's mean score was significantly different than Thompson's score with medium effect size (d = 0.75).

The 6th grade school attended variable, as well as the other background variables analysed in this section, were generated for use in a multiple linear regression analysis – with *Aspirations in science* as the dependent variable. Consequently, it is useful to examine background and component correlations with the dependent variable *Aspirations in science*.

4.5.2 6th grade component correlation matrix

Table 4.12 displays the matrix of correlations between variables used in the 6th grade multivariate regression (see Chapter 5). All correlations between *Aspirations in science* and the attitudinal components were significant, indicating strong bivariate linearity. For example, the largest correlation for the *Aspirations in science* component was that with *Experience of school science* (r = .709). Note that that the SES variable did not have a strong bivariate correlation with *Aspirations in science* (r = -.057); however, a significant correlation between

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[34] Although the SES measure did not have the expected (linear) relation with the 6th grade *Aspirations in science* measure, confidence in the reliability and validity of the measure was strengthened by its performance in the 6th-Extended grade sample analysis (detailed in Appendix 7 and discussed in Chapter 8).

[35] The Bonferroni post hoc procedure was utilized because it is considered to effectively control for Type I family-wise error rate for unequal sample sizes with equal variance (Tabachnick & Fidell, 2007).

variables is not a prerequisite for regression analysis – the two variables may show a strong association once other variables are controlled for. (Tabachnick & Fidell, 2013). Linear relations between variables are considered further in the examination of the assumptions of the multiple regression and are presented in Appendix 6.

Table 4.12. 6th grade bivariate correlations among variables.

Variable	*SES*	*ESS*	*FA*	*FAS*	*ISN*	*ISP*	*OSS*	*PAS*	*POS*	*SCS*
Socioeconomic status (SES)	-									
Experience of school science (ESS)	.000	-								
Family ambitions (FA)	.081	.270**	-							
Family attitudes to science (FAS)	.068	.570**	.383**	-						
Image of scientists-negative (ISN)	-.023	-.219**	.009	-.093*	-					
Image of scientists-positive (ISP)	-.057	.545**	.282**	.502**	-.089*	-				
Outside of school science (OSS)	.080	.481**	.286**	.437**	-.136**	.367**	-			
Peer attitudes to science (PAS)	.055	.564**	.141**	.357**	-.156**	.294**	.466**	-		
Peer orientation to school (POS)	.091*	.336**	.165**	.209**	-.028	.174**	.344**	.383**	-	
Self-concept in science (SCS)	.139**	.653**	.236**	.409**	-.219**	.424**	.415**	.452**	.290**	-
Aspirations in science	-.057	.709**	.210**	.564**	-.309**	.537**	.481**	.404**	.269**	.545**

Note: * $p < .05$, ** $p < .01$.

4.5.3 9th grade comparisons by group – Aspirations in science

4.5.3.1 Gender

As can be seen in Table 4.13, the mean scores on *Aspiration in science* were rather low for both the 9th grade girls and boys – with girls holding significantly lower scores than boys. An independent t-test of means showed that the gap ($\Delta M = 0.17$) between boys ($M = 2.93$, $SD = 0.82$) and girls ($M = 2.76$, $SD = 0.73$) science aspirations means was significant (t (423) = 2.282, $p = .023$), a small but meaningful effect ($d = .22$). In order to gain further insight into the 9th grade gender gap in science aspirations, the items that comprise the 9th grade *Aspirations in science* component were analysed by gender.

The response patterns on the four *Aspirations in science* items are shown in Figure 4.20, with the combined category of 'agree' and 'strongly agree' displayed within the 'agree' band. As shown in the figure, 9th grade boys had higher 'agree' and 'strongly agree' percentages on all items, compared to the 9th grade girls. There are three points of interest that emerge by comparing gender response patterns on these items. First, on item q11d an independent t-test showed that 9th grade boys ($M = 2.63$, $SD = 1.01$) and girls ($M = 2.37$, $SD = 0.82$) differed significantly in the extent to which they expressed a desire to become scientists (t (422) = 2.921, $p < 0.01$), with small effect size ($d = 0.28$). This result – low overall science aspirations as a group together with a gender difference – is also clearly seen in the response pattern on item q11d: while few 9th grade boys agreed (16.8%) they would like to become a scientist, the percentage of boys agreeing was still more than twice that of the girls (7.5%).

Second, for item 'q11e. I think I could be a good scientist one day', boys ($M = 2.75$, $SD = 1.10$) and girls ($M = 2.53$, $SD = 0.97$) means differed significantly, t (422) = 2.181, $p < 0.05$), also with small effect ($d = .21$). Specifically, only 13.2% of the 9th grade girls agreed or strongly agreed they could become a good scientist compared to 21.4% of the boys. Further, nearly half of the girls (47.8%) disagreed that they could be a good scientist one day, compared to more than one in three boys thinking the same (35.7 %).

Table 4.13. 9th grade group means for *Aspirations in science* (Scale 1 to 5).

Variable and values	*N*	*Mean*	*SD*	*Cohen's d*
Gender	*425*			
Boy	197	2.93	0.82	
Girl	228	2.76	0.73	
Gap		-0.17*		0.22
Generation of immigration	*416*			
1st	30	3.11	0.77	
2nd	249	2.85	0.76	
3rd	95	2.73	0.71	
4th	42	2.86	0.93	
Gap (1st vs. 4th)		-0.25		0.30
Home language use	*419*			
Never	21	2.88	0.80	
Once in a while	51	2.88	0.92	
About half of the time	114	2.83	0.74	
All or most of the time	233	2.84	0.75	
Gap (Never vs. All)		-0.04		
SES	*427*			
Quintile 1 (lowest 20%)	92	2.89	0.73	
Quintile 2	82	2.69	0.73	
Quintile 3	82	2.99	0.77	
Quintile 4	86	2.70	0.71	
Quintile 5 (highest 20%)	85	2.95	0.89	
Gap (Q1 vs. Q5)		0.06		
School	*427*			
Brahe HS	85	2.65	0.83	
Gibbs HS	62	2.81	0.73	
Kirchoff HS	97	2.84	0.69	
Meitner HS	87	2.91	0.69	
Molina HS	96	2.98	0.88	
Gap (high vs. low)		0.33		
Grand	425	2.84	0.77	

Note: * $p < .05$.

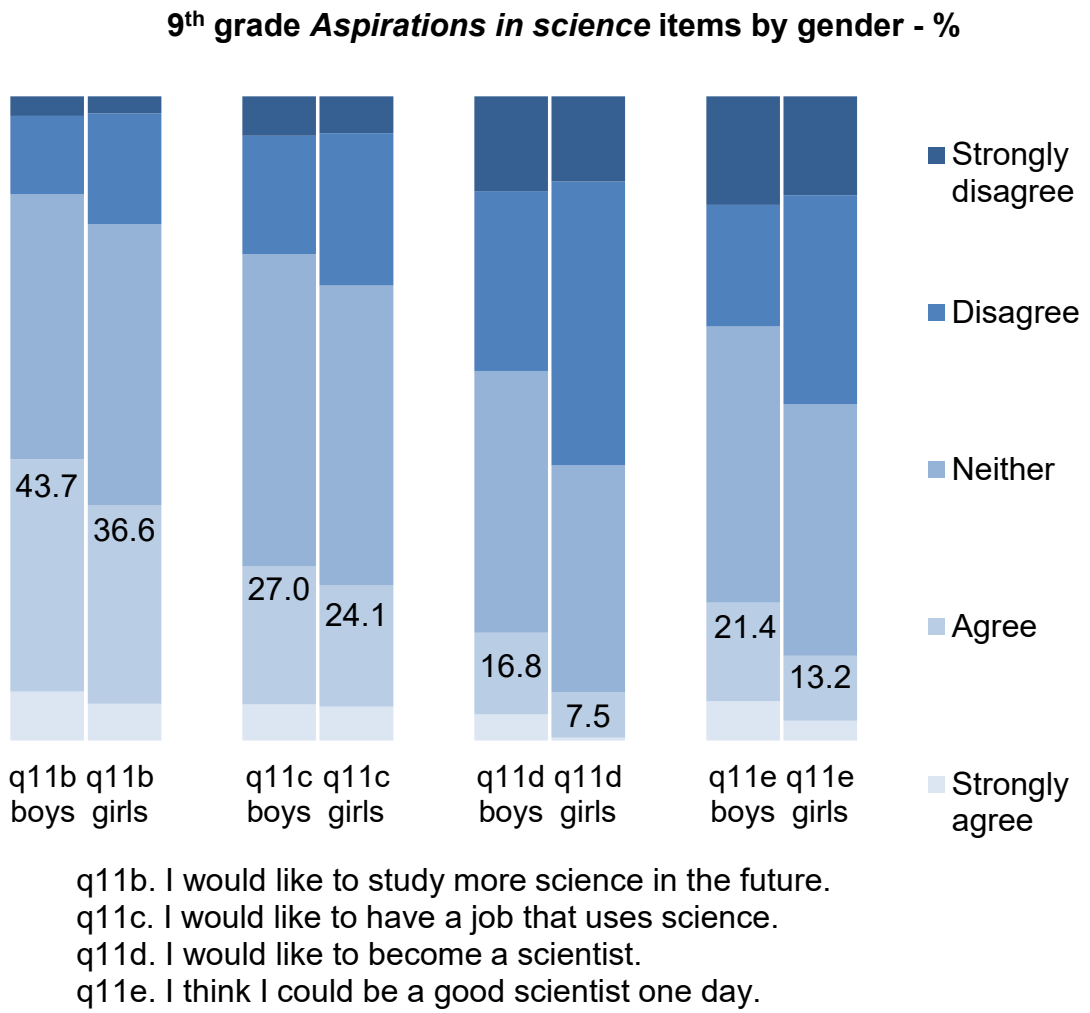

Figure 4.20. 9th grade item responses by gender for *Aspirations in science*.

Third, although not significant and as noted previously, the 9th grade girls also held lower mean than boys on both item 'q11b I would like to study more science in the future' and 'q11c I would like to have a job that uses science'. Taken together, the above results indicate that while 9th grade *Aspiration in science* item scores were low overall, the 9th grade girl's science aspirations were significantly lower than the 9th grade boys.

4.5.3.2 Generation of immigration, home language use, and socioeconomic status

Comparisons of 9th grade component means, by generation of immigration, home language use, and socioeconomic status showed only significant group differences by generation of immigration. Note the continuous decline in *Aspiration in science* scores from first-generation students (M = 3.11, SD = 0.77) to the third-generation students (M = 2.73, SD = 0.71) – the trend predicted from the theory of segmented assimilation (Portes & Zhou, 1993).

4.5.3.3 School attended

Examination of *Aspirations in science* by school attended showed that 9th grade students from Molina High School held the highest mean score (M = 2.98, SD = 0.88), while Brahe High School held the low score (M = 2.65, SD = 0.83). There were no significant group differences (F (4, 422) = 2.314, p = .057) on this variable.

4.5.4 9th grade component correlation matrix

The matrix of correlations between variables used in the multivariate regression is displayed in Table 4.14. Other than *Image of scientist-negative* and *Family ambitions*, correlations between *Aspirations in science* and the other science-related components were significant, indicating strong linear relations. For instance, the highest correlation for the *Aspirations in science* component was with *Experience of school science* (r = .500). The significant correlations between 9th grade *Aspirations in science* and its covariates are assessed further in the assumptions of the multiple regression analysis, described in Appendix 6.

Table 4.14. 9th grade bivariate correlations among variables.

Variable	*SES*	*ESS*	*FA*	*FAS*	*FI*	*ISN*	*ISP*	*OSS*	*PAS*	*POS*	*SCS*
Socioeconomic status (SES)	-										
Experience of school science (ESS)	-.011	-									
Family ambitions (FA)	.096*	.330**	-								
Family attitudes to science (FAS)	.054	.437**	.214**	-							
Family involvement (FI)	.119*	.567**	.378**	.346**	-						
Image of scientists-negative (ISN)	.002	-.114*	-.141**	-.052	-.057	-					
Image of scientists-positive (ISP)	-.012	.380**	.186**	.337**	.159**	.061	-				
Outside of school science (OSS)	.132**	.298**	.107*	.383**	.217**	-.033	.228**	-			
Peer attitudes to science (PAS)	-.009	.364**	.071	.190**	.194**	.041	.245**	.261**	-		
Peer orientation to school (POS)	-.045	.171**	.079	.064	.176**	.090	.203**	.111*	.611**	-	
Self-concept in science (SCS)	.087	.585**	.187**	.320**	.512**	-.180**	.170**	.282**	.213**	.021	-
Aspirations in science	.027	.500**	.073	.494**	.310**	-.045	.302**	.369**	.334**	.117*	.461**

Note: * $p < .05$, ** $p < .01$.

4.6 Summary of the Generation of Variables

This chapter detailed the generation of variables from the survey data of this study, including an empirical measure of science aspirations. A principal components analysis of the 6th grade data resulted in a reliable ten component solution, while the PCA of the 9th grade data yielded a reliable eleven-component solution. Analysis of the PCA solutions revealed a complex portrait of the East Los Angeles students' relation with science, displaying some positive science-related attitudes together with relatively low aspirations to become a scientist. The creation of five student background variables were explicated. The background characteristics generated were utilized to further examine the outcome variable of this study, *Aspirations in science*, with the 9th grade sample showing significant differences by gender. The degree to which the variables generated in this chapter predict science aspirations is presented in the next chapter.

CHAPTER 5 MULTIPE LINEAR REGRESSION ANALYSES

5.1 Introduction

The previous chapter detailed the generation of attitudinal and background variables from survey data – variables theorized to be associated with science aspirations. The third and fourth research question of this study ask: **Which attitudinal factors predict the strength of science aspirations in the two East Los Angeles samples?** and **What are the associations between science aspirations and gender, generation of immigration, home language use, and socioeconomic status?** In order to address these questions, this chapter reports the second phase of the data analysis: multiple linear regression analyses carried out to determine which attitudinal components and student background characteristics could best predict the 6th and 9th grade samples' science aspirations. This chapter begins with the multiple regression analysis of the 6th grade sample data and concludes with the 9th grade regression.

5.2 Multiple linear regression of 6th grade data

This section details the multiple linear regression (MLR) of the 6th grade sample data. First, the data's suitability for use in an MLR is considered. Then, the results of the MLR are presented. This section concludes with the analysis of the regression solution in terms of the theoretical background of this study.

5.2.1 Assumption testing – 6th grade

One aim of this study was to determine if the attitudinal variables extracted from the principal components analysis (PCA) explained a significant amount of the variance in *Aspirations in science*, after accounting for background effects. Consequently, hierarchical multiple linear regression was chosen as the mode of analysis. Hierarchical regression involves comparison of nested regression models, whereby the overall model is built by adding variables (or blocks of variables) to the previous model in steps (Tabachnick & Fidell, 2013). Importantly, applying this technique demonstrates whether or not newly added variables significantly improve the fit of the regression model. At the same time, newly entered variables can alter the strength of association between previously entered independent variables and the outcome variable (Tabachnick & Fidell, 2013).

In order to verify that the data were appropriate for a regression analysis, assumptions about the data were tested. The regression assumptions tested included: (1) ratio of cases to independent variables, (2) absence of outliers among the variables, (3) variables are normally distributed, (4) independent variables exhibit bivariate linearity with the dependent variable, and (5) absence of multicollinearity; the details of the assumption testing are located in Appendix 6. The 6th grade data were found suitable for regression analysis.

5.2.2 Results of the hierarchical multiple regression of the 6th grade data

The variables in the regression analysis were entered as blocks in three steps: (1) four background variables, (2) nine science-related attitudinal variables, and (3) school attended. Regression statistics are presented in Table 5.1. Model 1 shows that background characteristics did not significantly contribute to the prediction, ΔF (11, 523) = 1.209, p = .277), and accounted for only 2.5% of the variation in *Aspirations in science*. Introducing the nine attitudinal variables explained an additional 59.6% of variation in *Aspirations in science* and this change in R^2 was highly significant, ΔF (9, 514) = 87.358, $p < .001$. Lastly, the addition of school attended explained only an additional 0.4% of the variation in *Aspirations in science* and this change in R^2 square was not significant, ΔF (5, 509) = 0.992, p = .422. After all variables of interest were included in Model 3 of the regression analysis, three significant and five highly significant variables remained in the final model and produced an R^2 of .624 (F (25, 510) = 33.840, $p < .001$) for the prediction of *Aspirations in science*. The strongest predictor of 6th grade aspirations was *Experience of school science* (β = .375), with large effect[36]. Next, with moderate effect, was *Family attitudes to science* (β = .191). Following were *Image of scientist-negative* (β = -.153), *Image of scientists-positive* (β = .135), and *Outside of school science* (β = .127) – all with moderate effect. *Self-concept in science* (β = .102) was also found to be a significant predictor of *Aspirations in science,* although with small effect. Lastly, with the exceptions of Home language use-'Half of time vs. all the time'

[36] This study considers a magnitude of β > .05 to be a small but meaningful effect size, β > .10 to be a moderate effect size, and β > .25 to be a large effect size (see Keith, 1999).

Table 5.1. Hierarchical regression of 6th grade predictors on *Aspirations in science*.

Variable and values	Model 1	Model 2		Model 3	
Gender (girl)	.048	.014		.014	
Generation of immigration					
2nd vs. 1st	.041	.073		.078	
3rd vs. 1st	-.039	.013		.015	
4th vs. 1st	.072	.033		.035	
Home language use					
Half of time vs. all the time	-.054	-.057		-.060	*
Once in a while vs. all the time	-.027	-.018		-.015	
Never vs. all the time	-.066	-.026		-.024	
SES					
Q2 vs. Q1	-.011	.002		.007	
Q3 vs. Q1	.014	-.004		.002	
Q4 vs. Q1	.023	.009		.015	
Q5 vs. Q1	-.068	-.102	*	-.095	*
Attitudinal variable					
Experience of school science		.382	***	.375	***
Family ambition		.002		.000	
Family attitudes to science		.198	***	.191	***
Image of scientists-negative		-.153	***	-.153	***
Image of scientists-positive		.135	***	.135	***
Outside of school science		.118	***	.127	***
Peer attitudes to science		-.046		-.046	
Peer orientation to school		.038		.038	
Self-concept in science		.094	*	.102	*
School					
Halley vs. MMS				.028	
Hawking vs. MMS				.033	
Lorentz vs. MMS				.043	
Tesla vs. MMS				.013	
Thompson vs. MMS				-.026	
R^2	.025	.621	***	.624	***
ΔR^2	.025	.596	***	.004	

Note: * $p < 0.05$, *** $p < 0.001$.

(β = -.060) and SES-'Q5 vs. Q1' (β = -.095)[37], background characteristics and school attended were not found to be significant predictors of 6th grade *Aspirations in science*.

The results of the 6th grade regression analysis address the third and fourth research questions of this study:

3. Which attitudinal factors predict the strength of science aspirations in the sample? In particular, what is the role of student engagement in science-related activities outside of school, experiences of school science, family attitudes to science, images of scientists, peer attitudes to science, and science self-concept?

4. What are the associations between science aspirations and gender, home language use, generation status, and socioeconomic status?

In order to fully answer these research questions, and to gain a more complete understanding of these 6th grade students' science aspirations, the variables most closely related to *Aspirations in science* were explored and analysed in depth.

5.2.3 Analysis of the 6th grade regression model

The regression analysis of the 6th grade student survey responses quantifies this study's application of Koballa's (1988) model framing the relation between science-related attitudes and aspirations (see Section 2.5.1). Importantly, the final regression model showed that the attitudinal predictors of *Aspirations in science* differed considerably in significance and effect. Consequently, further exploration and analyses were carried out on the highly significant predictors *Experience of school science*, *Family attitudes to science*, *Image of scientist-negative*, *Image of scientist-positive*, and *Outside of school science*.

5.2.3.1 Experience of school science

By far the best predictor of *Aspirations in science* for the 6th grade sample was *Experience of school science* (β = .375, $p < .001$), nearly twice the magnitude of the next largest predictor

[37] The final regression model predicts students classified as Quintile 5 (β = -.095, $p < .05$) to have lower science aspirations in comparison to the lowest quintile (Quintile 1) – opposite of the theorized outcome. This suggests that the 6th grade SES measure did not have a linear relation with *Aspirations in science* and this result is discussed in Chapter 8 and Appendix 7.

Family attitudes to science (β = .191). The strength of this predictor in the regression analysis was not surprising, given that the two components were found to be very highly correlated (r = .709, $p < .01$). The grand and group means for this component are presented in Table 5.2. The overall mean score (M_{Grand} = 3.79, SD = 0.88) was slightly negatively skewed (G_1= -0.552, SE = .105), indicating that most 6th grade students held positive views of their school science experiences.

The regression result is particularly interesting given previous research highlighting the outsize influence school experiences have on Latino students at this age (e.g., Aschbacher, Ing, & Tsai, 2014), especially those classified as being of low SES (Woolley, Kol, & Bowen, 2008). Consequently, and given that SES significantly predicted science aspirations in the final regression model, group means for this component were analysed in order to detect group differences within the sample by socioeconomic status (as well as other background characteristics). Specifically, one-way ANOVAs were conducted on *Experience of school science*, where the null hypothesis (H_0) was equality in all population means, while the alternative hypothesis (H_1) was the difference in at least one mean.

The only group difference that emerged from the analysis of variance was by school attended (F (5, 532) = 14.786, $p < .001$), where Mendel MS (M = 4.35, SD = 0.65) had a significantly higher mean on the variable *Experience of school science* than all other middle schools. The effect sizes ranged from large between Mendel and Thompson (d = 1.28) to medium between Mendel and Hawking (d = 0.56). The difference in mean score by school attended was initially thought by the researcher to be a consequence of the (engineering science) curriculum adopted by one teacher – CD at Mendel Middle School. In order to explore this possibility, *Experience of school science* was examined further at the level of classroom teacher, displayed in Table 5.3. Interestingly, the highest mean score on *Experience of school science* was for students taught by AM at Mendel Middle School (M = 4.62, SD = 0.43, N = 56); the difference in mean scores between the two Mendel Middle School teachers was 0.78 ($\Delta M = M_{AM} - M_{CD}$ = 0.78). Thus, the relatively high mean *Experience of school science* score for Mendel Middle School was due primarily to AM's students, rather than CD's students.

Table 5.2. 6th grade mean scores on *Experience of school science* (Scale 1 to 5).

Variable and values	*N*	*Mean*	*SD*	*Cohen's d*
Gender	*538*			
Boy	246	3.86	0.88	
Girl	292	3.74	0.89	
Gap		-0.12		
Generation of immigration	*534*			
1st	28	4.04	0.78	
2nd	369	3.81	0.85	
3rd	98	3.63	1.00	
4th	39	3.96	0.90	
Gap (1st vs. 4th)		-0.08		
Home language use	*528*			
Never	32	3.74	1.05	
Once in a while	65	3.60	1.01	
About half of the time	112	3.83	0.89	
All or most of the time	319	3.82	0.83	
Gap (Never vs. All)		0.07		
SES	*538*			
Quintile 1 (lowest 20%)	100	3.80	0.81	
Quintile 2	115	3.71	0.80	
Quintile 3	108	3.85	0.91	
Quintile 4	105	3.79	0.98	
Quintile 5 (highest 20%)	110	3.82	0.92	
Gap (Q1 vs. Q5)		0.02		
School	*538*			
Halley MS	97	3.82	0.94	
Hawking MS	117	3.93	0.82	
Lorentz MS	62	3.46	0.85	
Mendel MS	86	4.35	0.65	
Tesla MS	89	3.67	0.87	
Thompson MS	87	3.39	0.83	
Gap (high vs. low)		0.96***		1.28
Grand	538	3.79	0.88	

Note: *** $p < .001$.

Table 5.3. 6th grade mean scores on *Aspirations in science* and *Experience of school science* by classroom teacher.

		Ais		*Eoss*	
School and Teacher	*N*	*Mean*	*SD*	*Mean*	*SD*
Halley_GR	64	3.24	0.85	3.88	0.91
Halley_GG	33	3.05	0.95	3.69	1.01
Hawking_ED	58	2.98	0.83	3.70	0.85
Hawking_JS	58	3.36	0.89	4.17	0.71
Lorentz_DC	34	2.72	0.63	3.23	0.80
Lorentz_MM	28	3.30	1.05	3.74	0.84
Mendel_AM	**56**	3.71	0.73	**4.62**	**0.43**
Mendel_CD	**30**	2.94	0.87	**3.84**	**0.69**
Tesla_JG	62	3.12	0.91	3.77	0.82
Tesla_FO	27	2.69	1.05	3.46	0.94
Thompson_BK	58	2.54	0.91	3.15	0.81
Thompson_SA	29	3.22	0.89	3.88	0.65
Grand	537	3.10	0.92	3.79	0.88

Notes: [a]*Ais* ≡ Aspirations in science.
[b]*Eoss* ≡ Experience of school science.

5.2.3.2 Family attitudes to science

The second strongest predictor of 6th grade *Aspirations in science* was *Family attitudes to science* ($\beta = .191$, $p < .001$). This result is unsurprising given that much previous research has found a family's relation with science to be an important influence on science aspirations for students at this age (e.g., Barmby et al., 2008; DeWitt et al., 2011, 2013), particularly Latino students (e.g., Aschbacher et al., 2010; Gilmartin et al., 2006). Table 5.4 displays group means on this component, which were analysed to detect significant differences within student groupings. As with *Experience of school science*, group differences were found only by school of attendance (F (5, 533) = 2.721, $p < .019$). Specifically, Mendel MS had a significantly higher *Family attitudes to science* mean ($M = 3.72$, $SD = 0.74$) than Thompson MS ($M = 3.28$, $SD = 0.92$), with medium effect ($d = 0.53$).

Table 5.4. 6th grade mean scores on *Family attitudes to science* (Scale 1 to 5).

Variable and values	*N*	*Mean*	*SD*	*Cohen's d*
Gender	*539*			
Boy	247	3.51	0.86	
Girl	292	3.54	0.86	
Gap		0.03		
Generation of immigration	*535*			
1st	28	3.74	0.89	
2nd	370	3.47	0.88	
3rd	98	3.61	0.76	
4th	39	3.72	0.76	
Gap (1st vs. 4th)		-0.02		
Home language use	*529*			
Never	32	3.55	0.82	
Once in a while	65	3.66	0.98	
About half of the time	112	3.56	0.79	
All or most of the time	320	3.48	0.85	
Gap (Never vs. All)		-0.07		
SES	*539*			
Quintile 1 (lowest 20%)	100	3.55	0.89	
Quintile 2	115	3.42	0.82	
Quintile 3	108	3.53	0.93	
Quintile 4	105	3.54	0.84	
Quintile 5 (highest 20%)	111	3.62	0.79	
Gap (Q1 vs. Q5)		0.07		
School	*539*			
Halley MS	97	3.64	0.82	
Hawking MS	118	3.51	0.87	
Lorentz MS	62	3.49	0.88	
Mendel MS	86	3.72	0.74	
Tesla MS	89	3.51	0.85	
Thompson MS	87	3.28	0.92	
Gap (high vs. low)		0.44*		0.53
Grand	539	3.53	0.86	

Note: * $p < .05$.

5.2.3.3 Image of scientist-negative

The third most influential predictor of science aspirations was *Image of scientist-negative* (β = -.153, $p < .001$). Group means for this component are presented in Table 5.5, with higher scores indicating a more unfavourable view of scientists. Overall, these students did not appear to hold strongly negative stereotypes of scientists ($M_{Grand} = 3.00$, $SD = 0.82$). One significant difference was found between group means: a one-way ANOVA showed mean differences by home language use (F (3, 524) = 4.036, $p = .007$). Post hoc Bonferroni procedure[38] indicated a significantly more negative image of scientists for students who spoke only English at home ($M = 3.40$, $SD = 0.81$) compared to students who always or almost always spoke another language at home ($M = 2.94$, $SD = 0.76$), with medium effect ($d = 0.58$). Greater clarity into the impact images of scientists had on these students' science aspirations is gained by exploring its complementary attitudinal component, the positive image of scientists, which is analysed next.

[38] The Bonferroni post hoc procedure was utilized because it is considered to effectively control for Type I family-wise error rate for unequal sample sizes with equal variance (Tabachnick & Fidell, 2007).

Table 5.5. 6th grade mean scores *Image of scientist-negative* (Scale 1 to 5).

Variable and values	*N*	*Mean*	*SD*	*Cohen's d*
Gender	*538*			
Boy	246	3.04	0.89	
Girl	292	2.96	0.75	
Gap		-0.08		
Generation of immigration	*534*			
1st	28	3.05	0.79	
2nd	370	2.93	0.80	
3rd	98	3.14	0.87	
4th	38	3.21	0.80	
Gap (1st vs. 4th)		0.16		
Home language use	*528*			
Never	32	3.40	0.81	
Once in a while	65	2.98	0.91	
About half of the time	112	3.12	0.88	
All or most of the time	319	2.94	0.76	
Gap (Never vs. All)		-0.46**		0.58
SES	*538*			
Quintile 1 (lowest 20%)	100	3.04	0.76	
Quintile 2	114	2.90	0.87	
Quintile 3	108	3.13	0.87	
Quintile 4	105	2.97	0.80	
Quintile 5 (highest 20%)	111	2.95	0.76	
Gap (Q1 vs. Q5)		-0.09		
School	*538*			
Halley MS	97	2.99	0.83	
Hawking MS	118	2.92	0.81	
Lorentz MS	61	3.10	0.85	
Mendel MS	86	2.93	0.79	
Tesla MS	89	3.10	0.88	
Thompson MS	87	2.99	0.74	
Gap (high vs. low)		0.18		
Grand	538	3.00	0.82	

Note: ** $p < .01$.

5.2.3.4 Image of scientist-positive

Image of scientist-positive was the fourth most closely related component to *Aspirations in science* in the 6th grade sample (β = .135, $p < .001$). Note that the grand mean on this component, shown in Table 5.6, was quite high for these 6th grade students ($M_{Grand} = 4.14$, $SD = 0.65$). Together with its moderately negative skewed ($G_1 = -.942$, SE = .105) distribution, this result suggests that most of these students hold quite positive views of scientists. While recognizing it is difficult to support absolute comparisons of the attitudinal measures utilized in this analysis, it is nonetheless intriguing that the mean rating of this component ($M = 4.14$, $SD = 0.65$) was significantly higher than that of *Aspirations in science* ($M = 3.10$, $SD = 0.92$)[39]. That is to say, these 6th grade students' very positive views of scientists and their work did not align with similarly positive views of themselves as future scientists.

As with the components previously examined, further insight into the strong association between 6th grade students' positive image of scientists and their science aspirations was expected to be obtained by examining the *Image of scientist-positive* component by student groupings. No ordinal relation was observed by socioeconomic status and no differences were found by gender. However, a one-way ANOVA did show group differences by generation of immigration (F (3, 530) = 3.37, p =.018). Post hoc Bonferroni procedure indicated a more positive image of scientist for the fourth generation of immigration ($M = 4.46$, $SD = 0.59$) compared to the second generation ($M = 4.12$, $SD = 0.64$) with medium effect size ($d = 0.55$), as well as compared to the third generation ($M = 4.13$, $SD = 0.64$, $d = 0.55$). This result suggests that the 6th grade students with the most positive image of scientists were those students whose families had been in the U.S. the longest.

One other group difference on this component was found by school attended (F (3, 530) = 2.353, p <.05), where Mendel Middle School ($M = 4.33$, $SD = 0.64$) held a higher mean than Thompson Middle School ($M = 4.03$, $SD = 0.62$) on the variable *Image of scientist-positive*,

[39]Specifically, for *Image of scientist-positive* ($M = 4.14$, $SD = 0.65$) and *Aspirations in science* ($M = 3.10$, $SD = 0.92$) a paired samples t-test comparison of means (t (536) = 30.27, $p < .001$) indicated a significantly higher mean for *Image of scientist-positive*, with large effect size ($d = 1.31$).

Table 5.6. 6th grade mean scores on *Image of scientist-positive* (Scale 1 to 5).

Variable and values	*N*	*Mean*	*SD*	*Cohen's d*
Gender	*538*			
Boy	246	4.18	0.61	
Girl	292	4.11	0.68	
Gap		-0.07		
Generation of immigration	*534*			
1st	28	4.09	0.75	
2nd	370	4.12	0.64	
3rd	98	4.13	0.64	
4th	38	4.46	0.59	
Gap (1st vs. 4th)		0.37*		0.55
Home language use	*528*			
Never	32	4.10	0.67	
Once in a while	65	4.28	0.50	
About half of the time	112	4.15	0.59	
All or most of the time	319	4.10	0.69	
Gap (Never vs. All)		0.00		
SES	*538*			
Quintile 1 (lowest 20%)	100	4.11	0.64	
Quintile 2	114	4.10	0.57	
Quintile 3	108	4.26	0.59	
Quintile 4	105	4.18	0.77	
Quintile 5 (highest 20%)	111	4.05	0.64	
Gap (Q1 vs. Q5)		-0.06		
School	*538*			
Halley MS	97	4.20	0.58	
Hawking MS	118	4.09	0.68	
Lorentz MS	61	4.09	0.58	
Mendel MS	86	4.33	0.64	
Tesla MS	89	4.11	0.72	
Thompson MS	87	4.03	0.62	
Gap (high vs. low)		0.30*		.46
Grand	538	4.14	0.65	

Note: * $p < .05$.

with medium effect size (d = .46). This result aligns with the outcome that, as a group, students at Mendel MS held the highest *Aspirations in science*, while students at Thompson MS held the lowest.

5.2.3.5 Outside of school science

Table 5.7 displays means on the fifth highly significant predictor of *Aspirations in science*, *Outside of school science* (β = .127, p < .001). This component assessed student participation in activities related to science, either with their family or of their own accord. These activities include reading about science, doing science kits, discussing science topics at home, and watching a program about science. The grand mean of 'once a semester' (M_{Grand} = 3.00, SD = 1.05), or about twice a year, indicates that there was little interaction with science outside of school for these 6th grade students – an understandable result given the severely disadvantaged neighbourhood within which they reside. Consequently, and recalling that SES was significant in Model 3, this component was analysed by socioeconomic status (as well as the other background characteristics); however, no group differences were found on this component.

Further analysis of *Outside of school science* was carried out by school attended, given the component's intrinsic connection to school. One-way ANOVA indicated group differences by school attended (F (3, 533) = 4.38, p =.001). Post-hoc Bonferroni procedure showed Mendel Middle School (M = 3.38, SD = 0.91) had a significantly higher mean for *Outside of school science* compared to Lorentz MS (M = 2.73, SD = 1.21, d = .61), Tesla MS (M = 2.88, SD = 1.02, d = .52), and Hawking MS (M = 2.85, SD = 1.07, d = .54) – all with medium effect size. It is worth noting that this result lines up with the analysis of the other four highly significant predictors showing that, as a group, students at Mendel MS held the most positive science-related attitudes and aspirations among the middle schools in the sample.

Table 5.7. 6th grade mean scores *Outside of school science* (Scale 1 to 5).

Variable and values	*N*	*Mean*	*SD*	*Cohen's d*
Gender	*539*			
Boy	247	2.99	1.10	
Girl	292	3.00	1.01	
Gap		0.01		
Generation of immigration	*535*			
1st	28	3.04	1.24	
2nd	370	3.00	1.02	
3rd	98	3.04	1.13	
4th	39	2.90	0.97	
Gap (1st vs. 4th)		-0.14		
Home language use	*529*			
Never	32	2.61	1.32	
Once in a while	65	3.10	1.05	
About half of the time	112	3.10	0.99	
All or most of the time	320	2.99	1.03	
Gap (Never vs. All)		0.39		
SES	*539*			
Quintile 1 (lowest 20%)	100	2.97	0.97	
Quintile 2	115	2.82	1.02	
Quintile 3	108	2.95	1.00	
Quintile 4	105	3.10	1.11	
Quintile 5 (highest 20%)	111	3.15	1.11	
Gap (Q1 vs. Q5)		0.18		
School	*539*			
Halley MS	97	3.09	1.01	
Hawking MS	118	2.85	1.07	
Mendel MS	86	3.38	0.91	
Lorentz MS	62	2.73	1.21	
Tesla MS	89	2.88	1.02	
Thompson MS	87	3.03	1.01	
Gap (high vs. low)		0.65**		0.61
Grand	539	3.00	1.05	

Note: ** $p < .01$.

5.2.4 Summary of the 6th grade regression

The hierarchical multiple regression of the 6th grade data produced five notable results. First, the attitudinal construct encapsulating students' experience of school science was by far the most influential predictor of student science aspirations and those experiences were generally quite positive. However, in this case positive attitudes were not matched by correspondingly positive aspirations. That is to say, despite the very positive science-related attitude, these 6th grade students did not tend to aspire to a future in science.

Second, although participating with science-related activities outside of school time was found to be significantly associated with science aspirations, overall, the 6th grade students reported low participation rates – corresponding to perhaps twice a year.

Third, while school attended was not found to be significant in the final regression model, average attitudinal scores for students attending one middle school (Mendel MS) were consistently the highest among the middle schools in this study. It was thought initially that the high scores were due to an engineering science curriculum adopted by one of the two participating teachers at that school. Upon further analysis, it was determined that the higher scores were the result of the very positive science-related attitudes of students taught by the other participating Mendel MS teacher; this teacher followed the standard 6th grade science curriculum.

Fourth, the hierarchical model showed that the strength of some background characteristics in Model 1 (e.g., gender and home language use) were reduced in the second model; their effect was mediated by the entry of attitudinal components at that stage. For example, Model 1 predicted 6th grade girls to have higher science aspirations than 6th grade boy (β_{Gender_M1} = .048). With the addition of attitudinal components to the model, the effect of gender on *Aspirations in science* was greatly diminished (β_{Gender_M2} = .014). This can be understood, for instance, by noting that *Experience of school science* in Model 2 was a highly significant predictor of science aspirations (β_{Eoss_M2} = .382, $p < .001$) and that overall boys were more positive about their experience of school science (M = 3.86, SD = 0.88) than girls (M = 3.74, SD = 0.89).

Lastly, in the final model only two background characteristics – Home language use-'Half of time vs. all the time' and SES-'Q5 vs. Q1' – significantly predicted 6th grade *Aspirations in science*.

5.3 Multiple linear regression of 9th grade data

This section describes the hierarchical multiple linear regression analysis carried out to determine which of ten attitudinal variables extracted from the 9th grade principal components analysis, as well as four additional background variables, could best predict the 9th grade students' *Aspirations in science*. The regression conducted on the 9th grade sample data employed the same analytical approach utilized for the 6th grade analysis (see Section 5.2).

5.3.1 Assumption testing – 9th grade

Assumptions checked in order to verify that the 9th grade survey data was suitable for a multiple regression included: (1) ratio of cases to independent variables, (2) absence of outliers among the variables, (3) variables are normally distributed, (4) independent variables exhibit bivariate linearity with the dependent variable, and (5) absence of multicollinearity. The results are reported in Appendix 6.

5.3.2 Results of the hierarchical multiple regression of the 9th grade data

The variables were entered in three blocks: (1) four background variables, (2) ten attitudinal components, and (3) school attended. Regression statistics are presented in Table 5.8. At Model 1 background characteristics did not contribute significantly to the prediction model, ΔF (11, 405) = 1.691, p =.073) and accounted for just 4.4% of the variation in *Aspirations in science*. Next, the block of ten attitudinal variables explained an additional 38.5% of variation in *Aspirations in science* and this change in R^2 was highly significant, ΔF (10, 395) = 26.600, $p < .001$. Lastly, adding the school attended explained only an additional 1.1% of the variation in *Aspirations in science* and this change in R^2 square was not significant, ΔF (4, 391) = 1.845, p = .120. Once all independent variables were included in Model 3 of the regression analysis, eight significant variables remained in the final 9th grade model and resulted in an R^2 of .439 (F (25, 391) = 12.251, $p < .001$) for the prediction of 9th grade *Aspirations in science*.

Table 5.8. Hierarchical regression of 9th grade predictors on *Aspirations in science*.

Variable and values	Model 1		Model 2		Model 3	
Gender (girl)	-.088		-.042		-.035	
Generation of immigration						
2nd vs. 1st	-.123		-.084		-.065	
3rd vs. 1st	-.198	*	-.117		-.091	
4th vs. 1st	-.081		-.093		-.080	
Home language use						
Half of time vs. all the time	-.016		-.012		-.015	
Once in a while vs. all the time	.009		.028		.036	
Never vs. all the time	-.009		.002		.001	
SES						
Q2 vs. Q1	-.041		-.035		-.033	
Q3 vs. Q1	-.057		-.071		-.068	
Q4 vs. Q1	.087		.024		.019	
Q5 vs. Q1	.083		.011		.010	
Attitudinal variable						
Experience of school science			.194	**	.202	**
Family ambition			.019		.013	
Family attitudes to science			.257	***	.250	***
Family involvement			-.059		-.059	
Image of scientists-negative			.021		.018	
Image of scientists-positive			.060		.061	
Outside of school science			.104	*	.101	*
Peer attitudes to science			.152	**	.147	**
Peer orientation to school			-.047		-.050	
Self-concept in science			.222	***	.248	***
School						
Brahe vs. KHS					.085	
Gibbs vs. KHS					.099	*
Meitner vs. KHS					.101	*
Molina vs. KHS					.114	*
R^2	.044		.429	***	.439	***
ΔR^2	.044		.385	***	.011	

Note: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

In the final model, the strongest predictor of 9th grade science aspirations was *Family attitudes to science* (β = .250), with large effect size. Next, also with large effect, was *Self-concept in science* (β = .248). Following, with moderate effect were *Experience of school science* (β = .202), *Peer attitudes to science* (β = .147), and *Outside of school science* (β = .101). Effects due to school of attendance were found as well, with Molina HS (β = .114), Meitner HS (β = .101), and Gibbs HS (β = .099) all significantly different from the reference school Kirchoff HS[40] in predicting *Aspirations in science*.

As with the 6th grade sample, the results of the 9th grade regression analysis correspond to the third and fourth research questions of this study:

3. Which attitudinal factors predict the strength of science aspirations in the sample? In particular, what is the role of student engagement in science-related activities outside of school, experiences of school science, family attitudes to science, images of scientists, peer attitudes to science, and science self-concept?

4. What are the associations between science aspirations and gender, generation of immigration, home language use, and socioeconomic status?

In order to address these questions and gain a clearer understanding of the 9th grade students' science aspirations, the significant predictors of 9th grade *Aspirations in science* were analysed in depth.

5.3.3 Analysis of the 9th grade regression model

Just one student background variable was found to be significantly associated with science aspirations in the regression analysis: generation of immigration in Model 1 ($\beta_{3rd\ vs.\ 1st} = -.198$, $p < .05$); however, by Model 3 the variable was no longer a significant predictor of *Aspirations in science*. While student background characteristics were not significant in the final prediction model, note the decrease in magnitude of several background coefficients with the entry of the attitudinal constructs in Model 2 of the regression. For example – and similar to the 6th grade regression analysis – the predictive strength of gender on 9th grade aspirations

[40] Kirchoff HS was chosen as the reference school as the largest school in the 9th grade sample.

in science is reduced by more than half (from β_{Gender_M1} = -.088 to β_{Gender_M2} = -.042) between models. This result suggests that the effect of gender on science aspirations is at least partially mediated by the attitudinal variables (see Cohen et al., 2003).

The attitudinal variables that emerged as significant predictors in the final 9th grade regression model varied in their strength of association with *Aspirations in science*. As a result, further analyses were carried out on *Family attitudes to science*, *Self-concept in science, Experience of school science*, *Peer attitudes to science*, and *Outside of school science*. While the 9th grade model was configured differently than the 6th grade model, it must be pointed out that three of these five constructs were analysed in the 6th grade regression analysis above. Consequently – and in order to avoid repetitive analysis – the remainder of this section focuses on features unique to the 9th grade regression model.

5.3.3.1 Family attitudes to science

Family attitudes to science (M_{Grand} = 3.38, *SD* = 0.75) was the single best predictor of 9th grade *Aspirations in science* (β = .250, $p < .001$). One-way ANOVAs were carried out on the group means displayed in Table 5.9, where the null hypothesis (H_0) was equality in all population means in a group and the alternative hypothesis (H_1) was the difference in at least one mean. No group differences were found.

Table 5.9. 9th grade group mean scores on *Family attitudes to science* (Scale 1 to 5).

Variable and values	*N*	*Mean*	*SD*
Gender	*422*		
Boy	197	3.40	0.81
Girl	225	3.35	0.70
Gap		-0.05	
Generation of immigration	*413*		
1st	30	3.44	0.77
2nd	248	3.36	0.72
3rd	95	3.28	0.78
4th	40	3.63	0.89
Gap (1st vs. 4th)		0.19	
Home language use	*416*		
Never	20	3.37	1.03
Once in a while	50	3.49	0.82
About half of the time	114	3.40	0.74
All or most of the time	232	3.33	0.71
Gap (Never vs. All)		-0.04	
SES	*424*		
Quintile 1 (lowest 20%)	74	3.33	0.65
Quintile 2	70	3.29	0.70
Quintile 3	114	3.31	0.68
Quintile 4	72	3.43	0.80
Quintile 5 (highest 20%)	94	3.53	0.89
Gap (Q1 vs. Q5)		0.20	
School	*424*		
Brahe HS	84	3.20	0.75
Gibbs HS	61	3.41	0.74
Kirchoff HS	97	3.44	0.72
Meitner HS	87	3.34	0.74
Molina HS	95	3.49	0.80
Gap (high vs. low)		0.29	
Grand	422	3.38	0.75

5.3.3.2 Self-concept in science

Self-concept in science was the next best predictor of *Aspirations in science* for the 9th grade sample ($\beta = .248$, $p < .001$). In this study, *Self-concept in science* refers to a student's self-assessment of their own ability to "be good at" science and is generally recognized as having an important influence on science aspirations (see Tytler & Osborne, 2012). Interestingly, the mean score on *Self-concept in science* ($M_{Grand} = 3.29$, $SD = 0.67$) was significantly higher[41] than that on *Aspirations in science* ($M_{Grand} = 2.84$, $SD = 0.77$). In other words, a relatively positive science-related attitude occurring together with low science aspirations.

Group means on this attitudinal component are displayed in Table 5.10. Given that Gilmartin et al. (2006) found in their study that "a positive science self-concept is by far the strongest 'predictor' of interest in the fields of Physical Science and Engineering" (p. 22), further analysis of *Self-concept in science* was carried out by student background characteristics. For example, while examination of component scores by gender shows that the 9th grade boys held a slightly higher mean ($M = 3.34$, $SD = 0.70$) than the 9th grade girls ($M = 3.24$, $SD = 0.64$), an independent sample t-test comparison of means (t (422) = 1.46, $p = .145$) showed that the difference was not statistically significant. Significant group differences for *Self-concept in science* means were found by school attended, F (4, 421) = 11.683, $p < .001$, with Bonferroni post hoc analysis indicating that students attending Kirchoff High School ($M = 3.62$, $SD = 0.60$) possessed a significantly higher science self-concept mean than all the other high schools in the study. The largest gap found was between Kirchoff HS and Gibbs HS ($M = 3.05$, $SD = 0.63$) with large effect ($d = .93$), while the smallest gap was with Molina High School ($M = 3.38$, $SD = 0.72$) with small effect ($d = .37$).

[41] While there is a difference in absolute mean rating for these components, it is likely that these attitudinal measures cannot support absolute comparisons and thus there may be no real-world significance in different mean scores. Nonetheless, a paired sample t-test comparison of means (t (425) = 12.199, $p < .001$) indicated a significantly higher mean for *Self-concept in science* ($M = 3.29$, $SD = .67$) compared to *Aspirations in science* ($M = 2.84$, $SD = 0.77$), with medium effect size ($d = .62$).

Table 5.10. 9th grade group mean scores on *Self-concept in science* (Scale 1 to 5).

Variable and values	*N*	*Mean*	*SD*	*Cohen's d*
Gender	*424*			
Boy	197	3.34	0.70	
Girl	227	3.24	0.64	
Gap		-0.10		
Generation of immigration	*415*			
1st	30	3.13	0.51	
2nd	249	3.30	0.69	
3rd	95	3.26	0.67	
4th	41	3.43	0.72	
Gap (1st vs. 4th)		0.30		
Home language use	*418*			
Never	20	3.47	0.68	
Once in a while	51	3.30	0.72	
About half of the time	114	3.25	0.62	
All or most of the time	233	3.30	0.68	
Gap (Never vs. All)		-0.17		
SES	*426*			
Quintile 1 (lowest 20%)	74	3.24	0.67	
Quintile 2	70	3.15	0.60	
Quintile 3	115	3.26	0.61	
Quintile 4	73	3.38	0.69	
Quintile 5 (highest 20%)	94	3.42	0.75	
Gap (Q1 vs. Q5)		0.18		
School	*426*			
Brahe HS	85	3.08	0.68	
Gibbs HS	62	3.05	0.63	
Kirchoff HS	97	3.62	0.60	
Meitner HS	87	3.22	0.57	
Molina HS	95	3.38	0.72	
Gap (high vs. low)		0.57***		0.93
Grand	424	3.29	0.67	

Note: *** $p < .001$.

5.3.3.3 Experience of school science

Experience of school science was the third most closely associated component with 9th grade *Aspirations in science* (β = .202, $p < .01$). The overall mean score on this component (M_{Grand} = 3.91, SD = 0.65) was moderately negatively skewed (G_1= -0.676, SE = .118), suggesting that most 9th grade students held positive views of school science. It is worth pointing out again the inconsistency between positive science-related attitudes and low science aspirations observed for the 9th grade students. More specifically, a comparison of means indicated that the mean rating of *Experience of school science* (M = 3.91, SD = 0.65) was significantly higher (t (426) = 30.980, $p < .001$) than the mean of *Aspirations in science* (M = 2.84, SD = 0.77) and with large effect (d = 1.49).

Table 5.11 shows group means for this component. Comparisons among groups found significant differences in mean scores only by school attended (F (4, 422) = 15.555, $p < .001$). Post hoc Bonferroni procedure showed that the three schools with the largest means (Kirchoff HS, Molina HS, and Meitner HS) possessed significantly different means than the two schools with the lowest means (Gibbs HS and Brahe HS). As an example, the largest gap between *Experience of school science* scores occurred between Kirchoff High School (M = 4.15, SD = 0.52) and Brahe High School (M = 3.57, SD = 0.72) and they differed with large effect (d = .93).

Table 5.11. 9th grade mean scores on *Experience of school science* (Scale 1 to 5).

Variable and values	*N*	*Mean*	*SD*	*Cohen's d*
Gender	*425*			
Boy	197	3.89	0.69	
Girl	228	3.93	0.62	
Gap		0.03		
Generation of immigration	*416*			
1st	30	4.02	0.73	
2nd	249	3.93	0.61	
3rd	95	3.86	0.68	
4th	42	3.88	0.77	
Gap (1st vs. 4th)		-0.14		
Home language use	*419*			
Never	21	3.82	0.75	
Once in a while	51	3.77	0.70	
About half of the time	114	3.92	0.67	
All or most of the time	233	3.95	0.62	
Gap (Never vs. All)		0.13		
SES	*427*			
Quintile 1 (lowest 20%)	74	3.87	0.58	
Quintile 2	71	3.86	0.66	
Quintile 3	115	3.91	0.60	
Quintile 4	73	3.98	0.61	
Quintile 5 (highest 20%)	94	3.93	0.78	
Gap (Q1 vs. Q5)		0.05		
School	*427*			
Brahe HS	85	3.57	0.72	
Gibbs HS	62	3.64	0.69	
Kirchoff HS	97	4.15	0.52	
Meitner HS	87	3.98	0.47	
Molina HS	96	4.08	0.64	
Gap (high vs. low)		0.58***		0.93
Grand	425	3.91	0.65	

Note: *** $p < .001$.

5.3.3.4 Peer attitudes to science

The variable *Peer attitudes to science* measures a student's evaluation of their peers' relation with science and was the fourth strongest predictor of 9th grade science aspirations (β = .147, $p < .01$). Table 5.12 displays group means for this component. The 9th grade mean score ($M_{Grand} = 2.93$, $SD = 0.62$) on this component corresponds to between "few" (scored as 2) and "some" (scored as 3) of these students' peers having positive attitudes towards science. This component's link to peers and peer groups suggests examination of component scores by specific groupings within the sample. For example, at this age these students' friendship groups tend to be fairly homogeneous with respect to gender (e.g., Shrum, Cheek, & Hunter, 1988). Accordingly[42], an independent samples t-test showed significant differences in mean scores by gender (t (418) = 2.445, $p < .05$), with boys ($M = 3.01$, $SD = 0.64$) reporting peers with more positive attitudes towards science than girls ($M = 2.86$, $SD = 0.59$), with small effect ($d = .24$).

An additional group difference was observed within generation of immigration (F (3, 407) = 5.893, $p = .001$). Bonferroni Post hoc procedure showed that first generation immigrants ($M = 3.36$, $SD = 0.75$) had a higher mean score on *Peer attitudes to science* than all other generations; the gap between the first and fourth generations ($M = 2.87$, $SD = 0.53$) had medium effect size ($d = .75$). These results suggest that in the 9th grade East Los Angeles sample, immigrant students' peer groups have more positive attitudes towards science than native born students' peer groups.

[42] Although not a significant predictor in the final regression model, the categorization of 9th grade girl resulted in a prediction of lower science aspirations (β = - 0.35).

Table 5.12. 9th grade group mean scores on *Peer attitudes to science* (Scale 1 to 5).

Variable and values	*N*	*Mean*	*SD*	*Cohen's d*
Gender	*420*			
Boy	194	3.01	0.64	
Girl	226	2.86	0.59	
Gap		-0.15*		0.24
Generation of immigration	*411*			
1st	30	3.36	0.75	
2nd	246	2.94	0.63	
3rd	95	2.84	0.51	
4th	40	2.87	0.53	
Gap (1st vs. 4th)		-0.49**		0.75
Home language use	*414*			
Never	20	2.98	0.70	
Once in a while	49	2.84	0.74	
About half of the time	113	2.91	0.57	
All or most of the time	232	2.95	0.60	
Gap (Never vs. All)		-0.03		
SES	*422*			
Quintile 1 (lowest 20%)	73	2.94	0.63	
Quintile 2	69	2.91	0.64	
Quintile 3	113	2.97	0.66	
Quintile 4	73	2.90	0.55	
Quintile 5 (highest 20%)	94	2.94	0.60	
Gap (Q1 vs. Q5)		0.00		
School	*422*			
Brahe HS	83	2.84	0.58	
Gibbs HS	62	2.90	0.65	
Kirchoff HS	97	2.92	0.53	
Meitner HS	87	2.98	0.63	
Molina HS	93	3.00	0.70	
Gap (high vs. low)		0.16		
Grand	420	2.93	0.62	

Note: * $p < .05$, ** $p < .01$.

5.3.3.5 Outside of school science

The fifth strongest predictor of 9th grade science aspirations was *Outside of school science* (β = .101, $p < .05$). Table 5.13 displays group means on this component, with the grand mean ($M_{Grand} = 2.27$, $SD = 0.82$) indicating that these students interact with science once or twice a year outside of school. Group means on this component were analysed to detect significant differences within student groupings. For example, 9th grade boys ($M = 2.39$, $SD = 0.85$) reported spending more time outside school with science than 9th grade girls ($M = 2.18$, $SD = 0.79$). This difference in mean scores by gender ($\Delta M_{Gender} = 0.21$) was found to be significant (t (423) = 2.674, p =.008), with small effect ($d = 0.26$).

Another group difference in means was found by socioeconomic status (F (4, 422) = 3.025, p = .018), although post hoc Bonferroni procedure comparisons did not reveal differences among quintiles. However, the largest gap among the SES quintiles was 0.33 between the highest SES quintile ($M = 2.49$, $SD = 0.85$) and the lowest quintile ($M = 2.16$, $SD = 0.80$), with small effect ($d = .39$); this indicates greater participation in science outside of school by the highest SES quintile, compared to the lowest quintile. Thus, this result suggests that, even in an area of low overall socioeconomic status, relative SES impacts this study's theorized influences on science aspirations.

Table 5.13. 9th grade group mean scores on *Outside of school science* (Scale 1 to 5).

Variable and values	*N*	*Mean*	*SD*	*Cohen's d*
Gender	*425*			
Boy	197	2.39	0.85	
Girl	228	2.18	0.79	
Gap		-0.21**		0.26
Generation of immigration	*416*			
1st	30	2.20	0.92	
2nd	249	2.26	0.83	
3rd	95	2.30	0.77	
4th	42	2.38	0.90	
Gap (1st vs.4th)		0.18		
Home language use	*419*			
Never	21	2.10	0.98	
Once in a while	51	2.36	0.95	
About half of the time	114	2.23	0.81	
All or most of the time	233	2.29	0.79	
Gap (Never vs. All)		0.19		
SES	*427*			
Quintile 1 (lowest 20%)	74	2.16	0.80	
Quintile 2	71	2.16	0.80	
Quintile 3	115	2.18	0.83	
Quintile 4	73	2.40	0.80	
Quintile 5 (highest 20%)	94	2.49	0.85	
Gap (Q1 vs. Q5)		0.33*		0.39
School	*427*			
Brahe HS	85	2.24	0.85	
Gibbs HS	62	2.42	0.87	
Kirchoff HS	97	2.32	0.73	
Meitner HS	87	2.20	0.79	
Molina HS	96	2.24	0.90	
Gap (high vs. low)		0.22		
Grand	425	2.27	0.82	

Note: * $p < .05$, ** $p < .01$.

5.3.4 Summary of the 9th grade regression

The hierarchical multiple regression of the 9th grade data yielded four interesting results. First, the three attitudinal variables *Family involvement* ($r = .310$, $p < .01$), *Image of scientist-positive* ($r = .302$, $p < .01$), and *Peer orientation to school* ($r = .117$, $p < .05$), while having significant small to moderate zero-order correlations with *Aspirations in science*, did not appear as significant predictors in the final regression model.

Second, family and peer attitudes towards science were quite influential on these 9th grade students' aspirations in science. These results support the theorized importance of social context on these students' science aspirations.

Third, the 9th grade students' experiences of school science were positive and positively impacted science aspirations. At the same time, participation in science outside of school science – which significantly predicted *Aspirations in science* – was quite low for these students. Taken together, these two results suggest that students' positive experiences with science in school might be most students only meaningful interaction with science. However, despite these 9th grade students reporting very positive experiences of school science, they also report relatively low science aspirations.

Lastly, there were significant school effects on these 9th grade students' science aspirations. It is interesting to note that the school with the lowest *Aspirations in science* predictor coefficient, Kirchoff High School, also had the highest mean scores on both *Experience of school science* and *Self-concept in science*. As well, Kirchoff HS ranked second or third on the remaining three significant attitudinal variables in the regression analysis (out of the five high schools in the study). Thus, while Kirchoff HS students generally reported more positive science-related attitudes relative to the other high schools, they were also predicted to have the lowest science aspirations.

5.4 Summary of the Multiple Linear Regression Analyses

This chapter detailed the regression analyses carried out to determine the best predictors of the East Los Angeles samples' science aspirations. There were five significant attitudinal predictors of *Aspirations in science* in the final 6th grade regression model: *Experience of school science*, *Family attitudes to science*, *Image of scientist-negative*, *Image of scientists-positive*, and *Outside of school science*. The 6th grade students' school science experiences had by far the most influence on their science aspirations – and they reported their school science experiences to be quite positive. It was shown that some background measures included in the 6th grade regression were mediated through the attitudinal variables.

The set of significant predictors for 9th grade *Aspirations in science* was configured differently than the 6th grade set. The five significant 9th grade predictors emerging in the final regression model were *Family attitudes to science*, *Self-concept in science*, *Experience of school science*, *Peer attitudes to science*, and *Outside of school science*. With the exception of school attended, background variables did not significantly predict 9th grade *Aspirations in science*. Differences (and similarities) between the 6th and 9th grade regression models are analysed in the next chapter.

CHAPTER 6 SAMPLE COMPARISONS AND CONTRASTS

6.1 Introduction

The previous two results chapters analysed this study's survey data in order to determine which components extracted from principal components analyses, as well as five student background characteristics, best predicted science aspirations. This chapter utilizes the results of the 6th and 9th grade analyses in order to address the fifth research question of this study: **Are there (cross-sectional) differences in science aspirations between the 6th and 9th grade samples?** An independent samples t-test showed that the mean *Aspirations in science* score of the 6th grade sample ($M = 3.10$, $SD = 0.92$) was significantly higher ($t\ (963) = 4.548$, $p < .001$) than that of the 9th grade sample ($M = 2.84$, $SD = 0.77$), with small but meaningful effect ($d = .30$). Beyond this basic comparison, this chapter provides a deeper understanding of the differences between the 6th and 9th grade students' science aspirations.

This chapter begins by comparing and contrasting the 6th and 9th grade samples' response patterns on the items that comprised the measure *Aspirations in science*. Next, the samples are examined together with respect to the background characteristics of the students. Then, both groups are analysed in terms of attitudinal measures extracted from the principal components analyses and utilized in the regression analyses. This chapter concludes by exploring the 6th and 9th grade samples by school attended.

6.2 Item responses for the 6th and 9th grade the *Aspirations in science* measure

The four items that made up both the 6th and 9th grade *Aspirations in science* (*Ais*) measure were: How much do you agree with these statements…

- *Ais*-1 I think I could be a good scientist one day.
- *Ais*-2 I would like to become a scientist.
- *Ais*-3 I would like to have a job that uses science.
- *Ais*-4 I would like to study more science in the future.

Figure 6.1 presents scores by percentage for the items that comprise the component *Aspirations in science*, with the percentage of the combined categories of 'agree' and

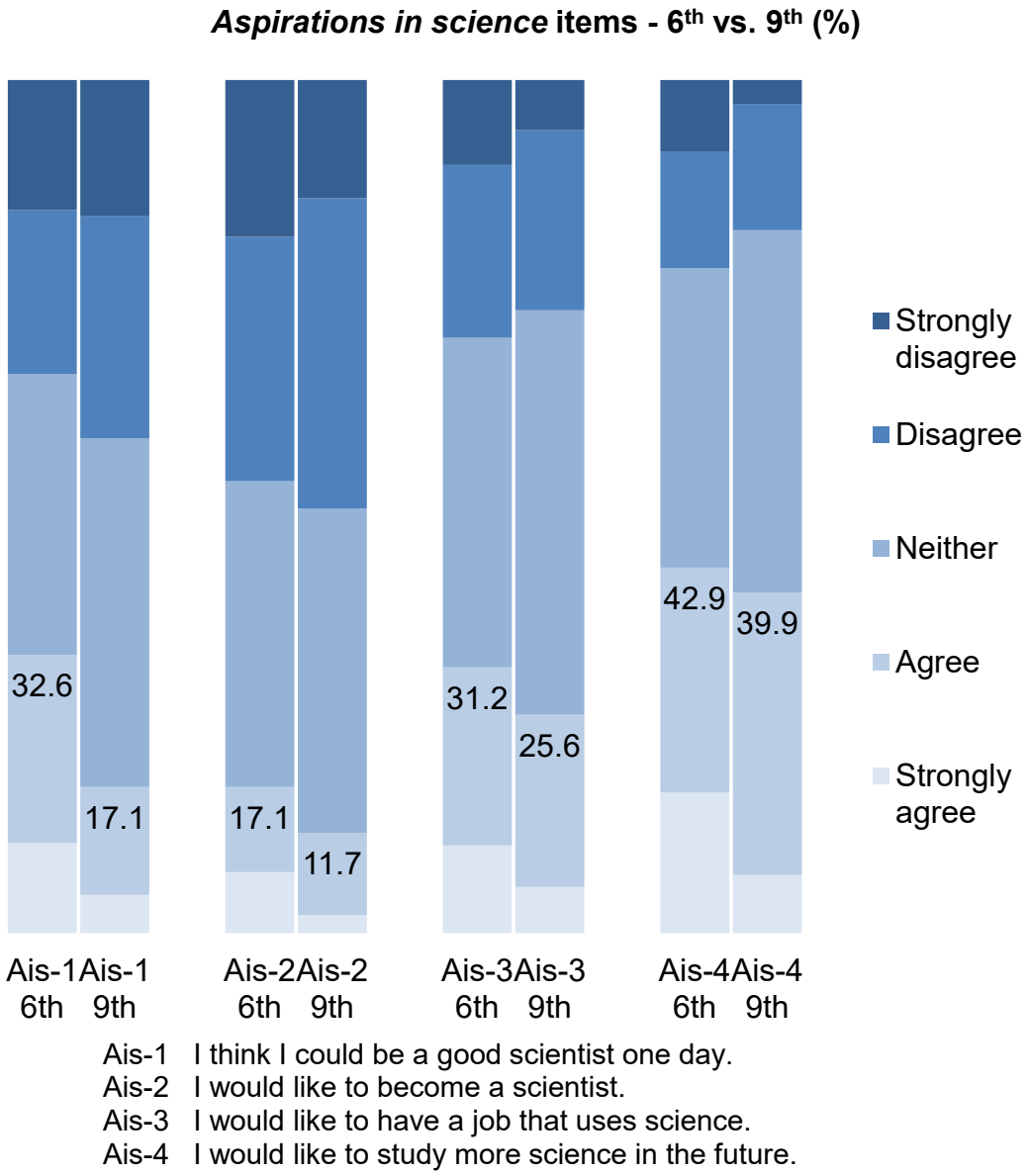

Figure 6.1. 6th and 9th grade item responses for *Aspirations in science*.

'strongly agree' displayed in the 'agree' band. As seen in the figure, the response patterns are more positive for the younger students than the older students – across all items.

For example, responses to item *Ais*-3 show that while one in three (31.2%) 6th grade students would like to have a job that uses science, just one in four (25.6%) 9th grade students think the same. The largest difference in positive responses is observed for item *Ais*-1, where 32.6% of 6th grade students, compared to 17.1% of 9th grade students, agreed that they could become a good scientist one day – a difference of more than 15%. Note that the lowest overall agree response rate for both samples was on item *Ais*-2: less than one in five (17.1%) 6th grade students and about one in ten (11.7%) 9th grade students agreed that would like to become a scientist in the future. Taken together the response patterns to these items suggest that, aside from studying more science, very few of either the 6th and 9th grade students plan for a future in the sciences.

6.3 Comparison of 6th and 9th grade Model 1 regression: Background characteristics

Model 1 of the hierarchical regressions analysed the effectiveness of certain background characteristics in predicting *Aspirations in science*. Table 6.1 displays Model 1 regression coefficients for both the 6th and 9th grade samples, with the difference in coefficients calculated as $\Delta\beta = \beta_9 - \beta_6$. Two interesting features emerge from comparisons of the sample data at Model 1. First, the effect of gender on *Aspirations in science*, although not significant, differed in direction depending on grade. Specifically, 6th grade girls were predicted to have slightly higher science aspirations ($\beta = .048$) than 6th grade boys. The opposite effect can be observed for the 9th grade sample, with girls predicted to hold lower aspirations than boys ($\beta = -.088$). Second, the socioeconomic status measure did not predict *Aspirations in science* in the same way for both samples. While no discernible linear relation between SES and science aspirations is observed in the 6th grade sample, the 9th grade SES measure predicted higher science aspirations for the highest SES quintiles (Q4 and Q5) – the association the SES measure was expected to have with *Aspirations in science*.

Table 6.1. Model 1 regression coefficients for 6th and 9th grade.

Variable and values	6th β	9th β		Δβ
Gender (girl)	.048	-.088		-0.14
Generation of immigration				
2nd vs. 1st	.041	-.123		-0.16
3rd vs. 1st	-.039	-.198	*	-0.16
4th vs. 1st	.072	-.081		-0.15
Home language use				
Half of time vs. all the time	-.054	-.016		0.04
Once in a while vs. all the time	-.027	.009		0.04
Never vs. all the time	-.066	-.009		0.06
SES				
Q2 vs. Q1	-.011	-.041		-0.03
Q3 vs. Q1	.014	-.057		-0.07
Q4 vs. Q1	.023	.087		0.06
Q5 vs. Q1	-.068	.083		0.15

Note: *$p < 0.05$.

Given the association of higher socioeconomic status with higher science aspirations in the 9th grade sample, the researcher investigated what other background characteristics students with "high" science aspirations had in common. That is to say, perhaps the student most likely to hold science aspirations was a first-generation 6th grade male, who spoke another language at home once in a while, and was of the highest socioeconomic quintile. In order to explore this line of thought, variables were configured for use in a logistic regression analysis. More specifically, the *Aspirations in science* (scale 1 to 5) variable was dichotomized: students holding mean scores of 4.0 or above were categorized as "holding" science aspirations, while students with scores less than 4.0 were categorized as "not holding" aspirations in science. Model 1 variables (gender, generation of immigration, home language use, and SES) were utilized as input variables for the logistic regression.

Although the logistic regression analysis produced no useful outcomes (and consequently is not reported here), it is nonetheless interesting to examine the dichotomized *Aspirations in*

Table 6.2. Percentage of 6th and 9th grade students holding science aspirations.

Variable and values	% with Aspirations 6th	9th	Δ%	N_{Total} 6th	9th
Gender					
Boy	20.9	11.2	-9.7	245	200
Girl	18.8	7.0	-11.8	294	228
Generation of immigration					
1st	3.6	13.3	9.8	28	30
2nd	20.9	9.6	-11.3	368	249
3rd	17.3	3.2	-14.2	98	95
4th	28.2	14.3	-13.9	39	42
Home language use					
Never	9.7	9.5	-0.2	31	21
Once in a while	18.5	13.7	-4.7	65	51
About half of the time	14.3	7.9	-6.4	112	114
All or most of the time	21.9	8.2	-13.8	319	233
SES					
Quintile 1 (lowest 20%)	7.0	4.1	-2.9	100	74
Quintile 2	21.7	8.5	-13.3	115	71
Quintile 3	30.8	7.0	-23.9	107	115
Quintile 4	21.0	9.6	-11.4	105	73
Quintile 5 (highest 20%)	18.2	14.9	-3.3	110	94
Grand	19.9	8.9	-11.0	537	425

science variable – providing further insight into the results of the Model 1 comparisons. Table 6.2 displays the percentage of students who "hold" science aspirations by grade and demographic group. Four interesting details emerge from simple comparisons of the 6th and 9th grade students. First, there was a substantial difference between grade levels with respect to the percentage of students who "hold" science aspirations: the overall percentage of 6th grade science aspiration "holders" (19.9%) is more than twice that of the 9th grade (8.9%) sample.

Second, contrasting by grade and gender together shows the gender gap in science aspirations "holders" to be larger for the older students. More precisely, the gender gap in 9th grade (Δ_{9th} = $\%G_{9th}$ - $\%B_{9th}$ = 7.0% - 11.2% = -4.2%) was double that of the 6th grade sample (Δ_{6th} =

$\%G_{6th}$ - $\%B_{6th}$ = -2.1%). Note in this comparison that the lowest percentage of science aspirations "holders" by grade and gender were 9th grade girls (7.0%).

Third, the pattern of science aspirations "holders" for the immigration generation variable differed by grade level. Examination of the 6th grade sample reveals a large difference in science aspirations between first-generation students (3.6%) and native-born students (17.3% and greater). This pattern is distinct from the 9th grade sample, where a non-linear (U-shaped) relation can be observed: smaller percentages of students in the second- and third-generation of immigration "hold" science aspirations compared to the first- and fourth-generations.

Lastly, it is worth noting the general linear increase in the percentage of 9th grade students "holding" science aspirations moving through the socioeconomic quintiles. For example, there was a difference of 10.8% between Quintile 1 (4.1%) and Quintile 5 (14.9%) in the percentage of 9th grade students who "hold" science aspirations. This result reinforces the idea (considered earlier in the Model 1 analysis) that 9th grade socioeconomic status is associated with science aspirations.

6.4 Comparison of 6th and 9th grade Model 2 regression

Table 6.3 displays Model 2 regression coefficients for the attitudinal variables used in predicting *Aspirations in science*. The 6th and 9th grade samples shared three significant predictor components (*Experience of school science*, *Family attitudes to science*, and *Outside of school science*), albeit with different strengths and relative importance. For example, relative to the 6th grade sample, the 9th grade sample's associations were stronger for *Family attitudes to science* ($\beta_9 = .257$, $\Delta\beta = \beta_9 - \beta_6 = .06$), lower for *Experience of school science* ($\beta_9 = .194$, $\Delta\beta = - 0.19$), and slightly lower for *Outside of school science* ($\beta_9 = .104$, $\Delta\beta = - 0.01$). Examining the 6th and 9th grade attitudinal variables' associations with *Aspirations in science* together yields four comparisons of note.

Table 6.3. Model 2 regression coefficients for 6th and 9th grade attitudinal variables.

Attitudinal variable	6th β		9th β		Δβ
Experience of school science	**.382**	***	**.194**	**	**-0.19**
Family ambition	.002		.019		0.02
Family attitudes to science	**.198**	***	**.257**	***	**0.06**
Family involvement	-		-.059		-
Image of scientists-negative	-.153	***	.021		0.17
Image of scientists-positive	.135	***	.060		-0.08
Outside of school science	**.118**	***	**.104**	*	**-0.01**
Peer attitudes to science	-.046		.152	**	0.20
Peer orientation to school	.038		-.047		-0.08
Self-concept in science	.094	*	.222	***	0.13

Note: *$p < 0.05$, **$p < 0.01$, ***$p < 0.001$.

First, note the much stronger influence school science had on the younger students' science aspirations, in comparison to the older students. Specifically, the 6th grade coefficient for *Experience of school science* ($\beta_6 = .382$, $p < .001$) – by far the strongest predictor of 6th grade science aspirations – is twice the magnitude of the 9th grade sample ($\beta_9 = .194$, $p < .01$). In contrast, the component with the strongest influence on 9th grade science aspirations was *Family attitudes to science* ($\beta_9 = .257$, $p < .001$), which was the second strongest component for the 6th grade sample ($\beta_6 = .198$, $p < .001$).

Second, comparing both group's regression coefficients for *Self-concept in science* highlights the role students' maturing self-awareness plays in science aspirations. Consider that *Self-concept in science* was the second largest predictor of 9th grade science aspirations ($\beta_9 = .222$, $p < .001$), while it was the least significant variable for the 6th grade sample ($\beta_6 = .094$, $p < .05$). As well, it is worth pointing out that the older students' average science self-concept rating was lower than that of the younger students. As shown in Table 6.4, there was a difference of $\Delta M = M_9 - M_6 = 3.29 - 3.50 = -0.21$ in *Self-concept in science* mean scores between samples, a small but meaningful effect size ($d = .29$).

Table 6.4. Mean scores on 6th (N = 539) and 9th grade (N = 428) grade attitudinal variables.

	6th		9th		
Attitudinal variable	*Mean*	*SD*	*Mean*	*SD*	Δ*M*
Aspirations in science	3.10	0.92	2.84	0.77	-0.26
Experience of school science	3.79	0.88	3.94	0.68	0.15
Family ambitions	4.73	0.39	4.66	0.52	-0.07
Family attitudes to science	3.53	0.86	3.38	0.75	-0.15
Family involvement[a]	-	-	3.79	0.74	-
Image of scientists-negative	3.00	0.82	2.94	0.71	-0.06
Image of scientists-positive	4.14	0.65	4.09	0.57	-0.05
Outside of school science	3.00	1.05	2.28	0.83	-0.72
Peer attitudes to science	2.88	0.95	2.93	0.62	0.05
Peer orientation to school	3.15	0.76	3.14	0.79	-0.01
Self-concept in science	3.50	0.77	3.29	0.67	-0.21

Note: [a]*Family involvement* did not emerge as a component in the 6th grade PCA.

Third, neither of the two components dealing with the image of scientists were found to be significant predictors for the 9th grade sample; an outcome understandable in light of the different developmental stages of these students and their aspirations. That is to say, it is quite conceivable that these 10- to 11-year-old children, who think any future self is possible, are influenced by images to a greater degree than the older, more "worldly" 14- to 15-year-old students.

Lastly, examination of Table 6.4 shows that the 9th grade students held a higher mean on just two of the ten components, compared to the 6th grade students. They were *Experience of school science* (Δ*M* = .12) and *Peer attitudes to science* (Δ*M* = .05) and this result will be examined together with school effects next, in the comparison of the Model 3 regression results.

6.5 Comparison of 6th and 9th grade Model 3 regression: School attended

The Model 1 and Model 2 regression analyses highlighted the importance of community in shaping both the 6th and 9th grade student's science aspirations, particularly school science experiences. As detailed in Sections 5.2 and 5. 3, the inclusion of school attended in Model 3 of the hierarchical regressions did not result in significant school effects for the prediction of 6th grade *Aspirations in science*, while significant differences were found among schools for the 9th grade sample. Yet at the same time, as seen in Table 6.5, *Experience of school science* continued to be highly significant for both samples ($\beta_6 = .375$, $p < .001$; $\beta_9 = .202$, $p < .01$). Further, it is worth noting that both samples possessed similar positive overall means on the *Experience of school science* component ($M_6 = 3.79$, $SD = 0.88$; $M_9 = 3.94$, $SD = 0.68$; $\Delta M = M_9 - M_6 = 0.15$).

Consequently, and given the difference in mean *Aspirations in science* scores between the 6th ($M_6 = 3.10$, $SD = 0.92$) and 9th grade samples ($M_9 = 2.84$, $SD = 0.77$; $\Delta M = M_9 - M_6 = - 0.26$), it is worth examining *Aspirations in science*, *Experience of school science*, and school attended for both samples together. Such a cross-sectional comparison provides a useful perspective on how a school might influence science aspirations. Specifically, this comparison provides a graphical representation of one aspect of the Model 3 regression, showing across schools how 6th grade students' science aspiration scores compare with 9th grade students holding similarly positive school science attitudes. The concept is illustrated Figure 6.2, a scatterplot in which each marker represents a school's mean *Experience of school science* (*Eoss*) score (horizontal axis) and mean *Aspirations in science* (*Ais*) score (vertical axis). The two diagonal lines represent the best fit *Ais* score across all (middle or high) schools at each *Eoss* value. The black circles represent the average *Eoss* and *Ais* score. Note that the slope of the best-fit line is greater for the 6th grade sample ($m_6 = .63$) than for the 9th grade sample ($m_9 = .37$). The different slope values indicate that more positive school science experiences accompany greater science aspirations for the 6th grade sample, in comparison to the 9th grade sample – an effective visualization of the regression models' predictions[43].

[43] While a useful visualisation of the data, it is recognised that correlations between school aggregate measures are not a sound basis for conclusions about effects on students. The overall finding from the regression analyses was that school effects on science aspirations were minimal, accounting for just 1% of additional variance at 9th

Table 6.5. Model 3 regression coefficients for 6th and 9th grade.

Variable and values	6th β		9th β		Δβ
Gender (girl)	.014		-.035		-0.05
Generation of immigration					
2nd vs. 1st	.078		-.065		-0.14
3rd vs. 1st	.015		-.091		-0.11
4th vs. 1st	.035		-.080		-0.11
Home language use					
Half of time vs. all the time	-.060	*	-.015		0.05
Once in a while vs. all the time	-.015		.036		0.05
Never vs. all the time	-.024		.001		0.02
SES					
Q2 vs. Q1	.007		-.033		-0.04
Q3 vs. Q1	.002		-.068		-0.07
Q4 vs. Q1	.015		.019		0.00
Q5 vs. Q1	-.095	*	.010		0.10
Attitudinal variable					
Experience of school science	.375	***	.202	**	-0.17
Family ambition	.000		.013		0.01
Family attitudes to science	.191	***	.250	***	0.06
Family involvement	-		-.059		
Image of scientists-negative	-.153	***	.018		0.17
Image of scientists-positive	.135	***	.061		-0.07
Outside of school science	.127	***	.101	*	-0.03
Peer attitudes to science	-.046		.147	**	0.19
Peer orientation to school	.038		-.050		-0.09
Self-concept in science	.102	*	.248	***	0.15

Note: *$p < 0.05$, **$p < 0.01$, ***$p < 0.001$.

grade – largely because Kirchoff High School's *Aspirations in science* mean was particularly low. Therefore, no firm conclusions about school effects can be drawn from this particular representation.

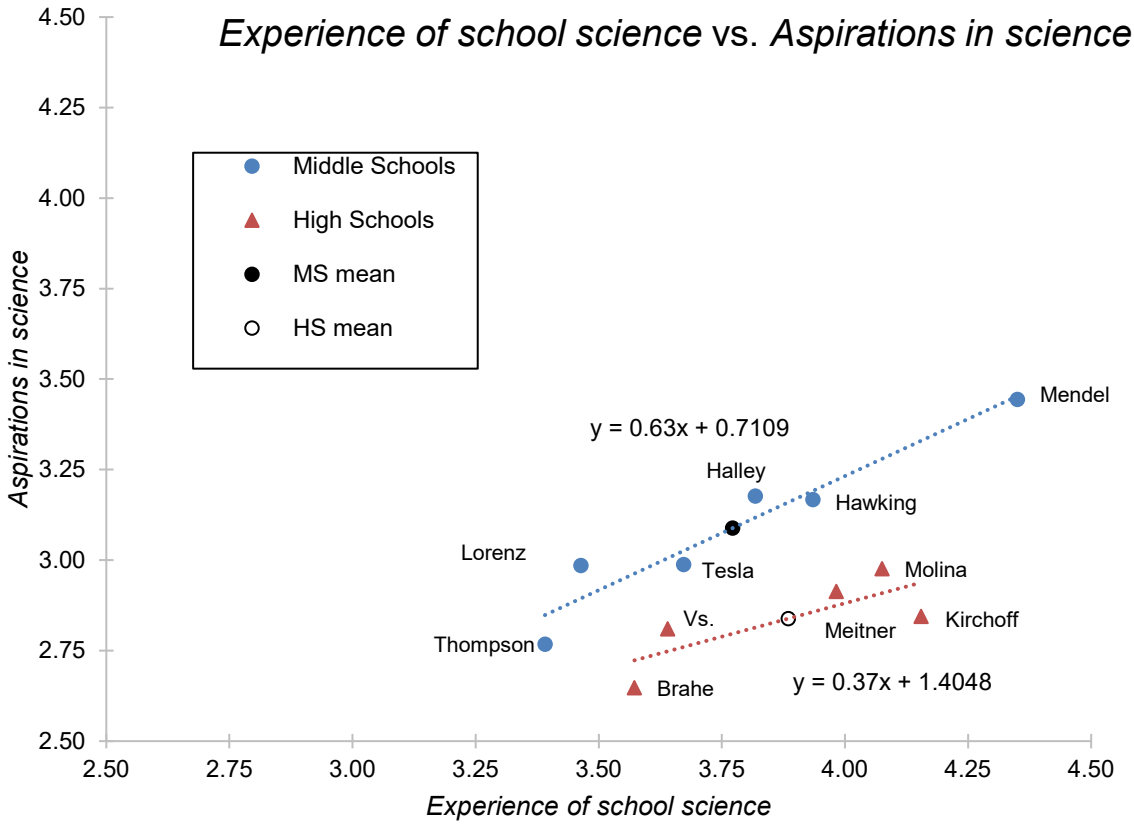

Figure 6.2. *Experience of school science* vs. *Aspirations in science* by school.

6.6 Summary of the Sample Comparisons and Contrasts

This chapter compared and contrasted the results of the 6th and 9th grade data analyses, with three notable outcomes. First, overall, the younger students held more positive science aspirations and science-related attitudes relative to the older students. Further, the difference in science aspirations by age also possessed a gender facet. Specifically, the largest percentage of students holding science aspirations was 6th grade boys, while the lowest percentage was 9th grade girls.

Second, measures related to social context impacted the older students' science aspirations to a greater degree than the younger students. For example, while in the final 9th grade regression model peer influences and socioeconomic status were significantly associated with

Aspirations in science, they were not significant in the final 6th grade model. These results suggest that the older students were more aware than the younger students of the educational impediments and challenges that living in an extremely disadvantaged area such as East Los Angeles presents. In other words, perhaps the older students had entered into a different stage of thinking about their life chances in comparison to the younger, more naive 6th grade students. Strengthening the concept that social context was more influential on older students' science aspirations than on younger students was that the attitudinal variable that most strongly predicted 9th grade science aspirations was their own family's attitudes towards science. In contrast, the younger students' science aspirations were most closely linked to their school science experiences.

Lastly, while school effects were significant for the older students' science aspirations, they were not significant for the younger students' aspirations[44]. One way in which school interacts with students' science-related attitudes and aspirations was presented through a graphical display of school and school science experiences together, showing that more positive school science experiences accompany greater science aspirations for the 6th grade sample, in comparison to the 9th grade sample.

[44] Although the results indicated school was associated with 9th grade science aspirations at a single point in time, the results cannot be used to infer that intentional efforts to "improve" the school will also improve science aspirations. This study was not designed to ascertain whether school was causally related to science aspirations.

CHAPTER 7 TEACHER INTERVIEWS

7.1 Introduction

This chapter presents the methods and analysis of member check interviews conducted with ten teachers who participated in this study. Lincoln and Guba (1985) describe member checking as the process "whereby data, analytic categories, interpretations, and conclusions are tested with members of those stakeholding groups from whom the data were originally collected, [and] is the most crucial technique for establishing credibility[45] [for the findings]" (p. 315). Accordingly, interviews were designed to obtain teachers' perspectives on the outcomes of the survey data analysis. This chapter begins with a description of the methods[46] used in the member check interviews. Next, the analysis of the data acquired in the interviews is detailed. Lastly, the findings of the interview data analysis are presented, discussed relative to the literature in Chapter 8.

7.2 Methods

7.2.1 Design

Once this study's survey data had been collected and analysed, teachers who had participated in the main study were contacted and asked to take part in a brief (20 minute) semi-structured interview. The aim of the interviews was to obtain participants' perspectives on the results of this study's data analysis. More specifically, interview questions were designed to elicit teachers' insights into the science-related attitudinal constructs and background measures that significantly predicted their students' science aspirations (see Appendix 8 for the interview questions). Consistent with the aim of the interviews, the format of semi-structured interview was selected; it allows the interviewer to ask additional questions that "follow up" on interesting interviewee responses (see Robson, 2011, p. 280).

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[45] Lincoln and Guba (1985) argue that credibility is qualitative analysis's "substitute for… internal validity" (p. 296).

[46] As the decision to interview teachers was taken approximately two years after the main survey data was gathered, it was thought appropriate to place the interview methods, analysis, and findings together in a separate chapter.

Due to the limited time frame of the interviews (20 minutes), the set of questions dealing with attitudinal constructs focused only on the three constructs most closely related to *Aspirations in science* at each grade level. Questions about student characteristics and science aspirations included the topics of gender, generation of immigration, home language use and socioeconomic status. Note that the interviews were planned and conducted approximately two years after the student surveys were administered; thus, the reliability of the teachers' recollections could be questioned. However, every participant had remained at the same school and teaching at the same grade level when the interviews were carried out (see Table 7.1 below). Consequently, it was thought that the teachers' views and recollections would be sufficient for the purposes of the interviews.

7.2.2 Ethical considerations

The member check component of this research study received approval from the Research Ethics Committee at the University of Oxford (CUREC 1A form in Appendix 8), separate from that of the pilot and main study. The approved procedure applied to obtain informed consent was IDREC 15, Version 1.3. This protocol is used for research on teachers and teaching in educational settings for typically developing students – appropriate for the planned teacher interviews.

Ethical considerations for this research included maintaining data protection and informed consent. Data was captured, transferred, and stored securely per Protocol 15. All references to individuals made within this thesis used pseudonyms, and thus anonymity is upheld. All consent forms and individual paper records are kept in a locked filing cabinet at the researcher's field office. Anonymized data keys are stored separately from the data sets. The anonymized data in Word format is securely stored by the researcher on password encrypted storage media. The researcher's supervisors have copies of this data, also password encrypted. Electronic data will be stored indefinitely, while hard copy data will be destroyed five years after this project ends. Informed consent from all participants was attained through use of letters of information and consent forms (see Appendix 8). It was stressed throughout that participation was voluntary, and that consent could be withdrawn at any time.

7.2.3 Participants

All teachers who participated in the main study were invited to take part in the interview process; of the 19 participating teachers, nine agreed to be interviewed. One additional science teacher, who did not take part in the survey but who had taught at several of the participating schools spanning a thirty-five-year career, volunteered to be interviewed. Some descriptive details of the participants (May to September 2018) are displayed in Table 7.1.

As a group, the teachers were very experienced: the majority of the teachers had more than ten years' experience (9 of 10); two had near thirty. Nine of the ten participants were male, including five Latinos, three White and one Black teacher. The sole female participant was an Asian-American with a degree in Biology and 17 years teaching experience. Only two of the six middle school teachers held a STEM degree, while all four high school teachers had earned a degree in a STEM field.

Table 7.1. Teacher interview participant descriptive details.

Teacher	*School*	*Sex*	*Age*	*Ethnicity*	*Years teaching*	*STEM major*
GG	Halley MS	M	47	Latino	22	N
AM	Mendel MS	M	43	Latino	18	Y
CD	Mendel MS	M	65	White	28	N
FO	Tesla MS	M	45	Latino	20	Y
BK	Thompson MS	M	35	White	6	N
SA	Thompson MS	M	42	Latino	12	N
SC	Brahe HS	M	36	Latino	12	Y
MV	Gibbs HS	M	61	White	22	Y
JM	Kirchoff HS	F	42	Asian	17	Y
JW[a]	Kirchoff HS	M	60	Black	32	Y

Note: [a]This teacher had also taught previously at Hawking MS.

7.2.4 Data collection – interview procedures

For the participants' convenience, interviews were conducted in the classroom of the teacher being interviewed. Prior to asking interview questions, the researcher summarized the results of the survey analysis pertinent to the teacher – middle school or high school – using graphs and tables; the researcher answered any questions the teacher had regarding the study's results. Once a teacher was familiar with the results the interview began. The teachers were asked three sets of questions: questions about student background characteristics, questions about attitudinal components, and questions about implications and interventions. The questions were designed to be as open and non-leading as possible (see Appendix 8 for interview questions). Although all teachers were asked the same questions, the interviews were flexible and the order of the questions sometimes varied; some teachers were asked additional questions to clarify or follow up on an initial response. Interviews were audio-recorded, with participants' consent, and typically lasted between 20 to 40 minutes. The interviews were transcribed verbatim by the researcher, omitting only unnecessary repetitions and fillers (see Appendix 8 for sample interview data). The analysis of the transcribed interviews is presented next.

7.3 Data Analysis

7.3.1 Initial coding and familiarization with the data

The data analysis began with coding hard copies of the interview transcripts using both Initial Coding and In Vivo methods. Initial Coding is considered appropriate for interview transcripts and "is intended as a starting point to provide the researcher with analytic leads for further exploration" (Saldaña, 2015, p. 81). Employing the Initial Coding method allowed data to be reduced to discrete units, such as phrases and sentences, which were then analysed to detect differences and similarities within the data set. In Vivo Coding was utilized to extract terms used by the participants (e.g., "science is challenging") which furthered the researcher's "understanding of [the participants] cultures and worldviews" (Saldaña, 2015, p. 74). In order to illustrate the coding process, two data codes and the data assigned to the codes are shown in Table 7.2. The two codes displayed in the table (Math as barrier, Math as language) were later

Table 7.2. Example data codes with data.

Code	*Data*
Math as barrier	SA: Science could be challenging for these students. It requires them to be good at math and English. JW: if the student does not have a good background in math, or a positive attitude towards math, they tend not to do as well. SC: Because their math skills are so poor when they enter our high school. AM: So, if they are going to connect to a science career, they're going to have master the hardest part from their perception, which is math. AM: math is such an abstract concept to them.
Math as language	AM: math is a language. AM: It's learning a new language when they are already trying to learn a new language of English. JW: Math is the language of science.

located in the category *Language use – Math as a third language*, which is described, along with the other categories of the coded data, next.

7.3.2 Categories and themes of the data

Once the data were coded, the codes were analysed and placed into categories with shared characteristics and related response patterns; the analysis at this point drew upon the theoretical perspectives of this study. That is to say, as the interview questions asked about specific concepts and constructs, it was important to analyse the data with respect to the theory organizing those concepts and constructs. For example, codes that included socioeconomic factors were generally grouped together (a graphical presentation of the first iteration of categories and their relations are shown in Figure A8.1). After several coding cycles the data were organized into seven categories of influences on science aspirations, which are detailed and analysed in the next section.

7.4 Findings

This section presents and analyses the seven categories of responses found in the interview data. Category names were based on the construct or background characteristic that typically elicited a group of coded responses, together with a phrase taken from that section of the data. For example, *Family attitudes to science – "Nothing in their lives revolves around science"* categorised data codes that emerged from questions asking about the attitudinal construct *Family attitude to science* and science aspirations. This section ends with the one theme that subsumed the seven categories – East Los Angeles subculture.

7.4.1 Family attitudes to science – "Nothing in their lives revolves around science"

This category encompassed the set of coded responses to interview questions about *Family attitude to science*; this attitudinal component was the best predictor of 9th grade *Aspirations in science* and the second-best predictor of 6th grade science aspirations. Although the teachers were asked to comment on the relation between the two variables, most of the teachers discussed the more general relation between students' families and careers *from* science[47]. This category of responses described families that were not involved with science in any form, which in turn accounted for the observed (low) family attitudes towards science. For example, six of the ten teachers pointed out that these students' parents tended to be employed as manual labour and, as a result, would not typically have contact with science. It would follow, the teachers explained, that science and science careers would not be topics of interest or discussion at home. As one middle school teacher noted "most of the families are hardworking people who work, let's say for example, in factories... or hard labor jobs. And nothing in their lives revolves around science" (GG). Extending this line of thought, two teachers pointed out that if no one in a student's family was involved with science, then that student probably would not see science as a career pathway – in effect lowering their science aspirations. For example, MV explained that his students "don't see their parents – or their family or their neighbors – doing it [science], even though they're doing it at school. They talk about earning a living and so it's, you know… so they don't see it as a future".

[47] To clarify, the term careers *from* science refers to "the other constituents of STEM (and STEMM), namely technology, engineering and mathematics (and medicine)" (Wong, 2015, p. 981).

7.4.2 Experience of school science – "I have to master this math part to actually be able to do this out in the real world"

The best predictor of 6th grade *Aspirations in science* and the third best predictor of 9th grade science aspirations was *Experience of school science*. Most of the teachers (seven of ten) were unsurprised when it was pointed out to them that, for both grade samples, students generally responded positively to the school science items on the survey. They pointed out that, generally, they endeavoured to make science class enjoyable for their students. Making science class enjoyable meant including as many hands-on activities and experiments as possible, particularly at the group level:

> Speaking from my perspective, the students who engaged in hands-on science just loved science. That was their experience of school science. The more a teacher drifted away from hands-on, the less enthusiastic I found the students to be. I would visit many science classrooms and I would see that if they're sitting, they're reading or writing – not very enthusiastic, from my perspective. But if they're engaged in hands-on activities – very enthusiastic. Because, again, it allows students to do what they do best. That is, move and talk. (JW)

While making science class enjoyable was a priority for these teachers, they also expected their students to work towards becoming proficient in the class content – a process which was not always enjoyable for the students. For example, while commenting on data analysis, AM noted that "when it came down to the analytical part and we had to use math[48] for analysing whatever it is we were experimenting on... that's where they realize that 'Oh, I have to master this math part to actually be able to do this out in the real world' ". Consequently, according to these teachers, both the enjoyment and the difficulty of school science acted in tension on their students' science aspirations. That is to say, this category of responses to interview questions suggested that while the teachers thought school science was enjoyable for their students, they also thought it could act to diminish science aspirations.

[48] The "math" AM refers to is the level of Algebra necessary, for example, to graph a line.

7.4.3 Outside of school science and Self-concept in science

The two other significant predictors of science aspirations shared by both grade levels were *Outside of school science* (*Ooss*) and *Self-concept in science* (*Scis*). When asked about the connections between these two constructs and science aspirations, the majority of the teachers suggested that the relations were structured by socioeconomic and cultural factors. Further, many teachers thought that social, cultural, and economic factors specific to East Los Angeles were the primary mechanisms driving their students' science aspirations. For instance, when asked for his thoughts regarding the relation between *Ooss* and science aspirations, BK responded "I think I just keep going back to the sociocultural factors at the macro level[49] because...Okay... I just don't have a lot to add". As another example, when discussing the influence *Scis* on science aspirations, five of the ten teachers pointed out that most of their students found science class challenging; as a result, they thought science class could reduce science self-concept. Two reasons were cited for the "challenge" of science class: low math skills and language use in the science classroom. In turn, teachers linked both reasons to sociocultural factors characteristic of East Los Angeles and those factors are analysed next.

7.4.4 Language use – Math as a third language

Six of the ten science teachers thought language played an important role in their students' science aspirations, in three connected ways. First, teachers noted that many of their students were not proficient in English and struggled with the type of "academic" English used in the science classroom. Consequently, students' limited fluency in "academic" English adversely affected their science learning and, as a result, (adversely) impacted their science aspirations. Asked to expand on the topic of their students' limited proficiency in English, several teachers suggested that the issue was directly connected to their home language use. More specifically, the teachers pointed out that these students learned the English language with limited support at home, with "academic" English language even less supported. Further, some teachers thought that rather than support learning at school, students' home language use hindered it. For example, when asked about home language use and academics BK noted "Sometimes

[49] The "macro level" BK refers to is large-scale or general social and cultural factors, such as endemic poverty and established Latino gender roles.

what happens is you get the worst of both cultures, you know? They get the bad language in English and they get the bad language in Spanish. And so, it's [sic] not really 'educated' at either level".

A second facet of the relation between language and science aspirations emerging from the interviews was the idea of "math as the language of science", with four teachers referring to this concept. To clarify, math was considered a language by these teachers because relations in the sciences are typically described by mathematical expressions, rather than written words. In general, these teachers thought that their students' (low-level) math skills acted to hinder the development of positive science aspirations. For example, JW noted "As math becomes more a part of science, especially the physical sciences, if the student does not have a good background in math, or a positive attitude towards math, they tend not to do as well". As a result, JW explained, those students that did not "do well" in science class would not likely hold high science aspirations.

The third insight into the connection between language and science aspirations involved both limited English proficiency and "math as a language". More specifically, several teachers pointed out that as well as the English language, their students were simultaneously learning the "math" language. As a result, these teachers thought the simultaneity of language learning adversely impacted learning in science class. AM provided a useful observation on the impact language had on learning science for these students:

> If you've already mastered a language, let's say the English language … you've already mastered that one language. Then you move to the second language of math – because math is a language. They [his students] are not only trying to master that other language [math] as well as perfecting the English language – these guys are trying to master three or four at the same time. And that language of math becomes third or fourth in the value system. That's why it becomes more complicated. (AM)

In other words, these students were still in the process of mastering the languages essential to learning science (i.e., academic English and math), impeding their learning of the school science curriculum.

7.4.5 Gender – "So, you can't have both"

The results of the survey analysis indicated that gender was not a significant predictor of *Aspirations in science* for either East Los Angeles sample. However, when asked about gender every teacher in the interviews thought that gender *did* play a role in their students' science-related attitudes and aspirations. When asked to elaborate on why they thought gender influenced their students' science aspirations, the teachers suggested two underlying reasons: (1) girls tended to be better students and (2) gender roles in Latino culture. For example, four of the ten teachers highlighted how much better prepared and motivated academically the girls were in comparison to the boys, at both the 6th and 9th grade levels. SC noted that the girls "seem to want to get ahead, they want to be something and so science is also a part of it". On the other hand, boys tended to be "immature" and less academically inclined. As a result, the teachers found that girls generally outperformed boys in their science classes.

Gender roles within the Latino family were also cited by five of the ten teachers as influencing their students' science aspirations. Specifically, girls in Latino culture are traditionally "groomed" to stay at home and take care of the "homelife", while boys are expected to find work as soon as possible and "contribute". JW pointed out that the effects of the two gender differences above acted in opposition and clearly impacted girls' science aspirations:

> So, you can't have both. You can't have people – and I've had some of the best students in the world – you can't have people moving towards science and have their parents pulling them back. I sent a girl to Berkeley. I finally talked to her dad and said "You can't hold this girl back!". This was one of the best students I ever had. And her dad did not want her to go. I have had several students like that. (JW)

7.4.6 Generation of immigration – "They tend to become a little more relaxed at learning"

Eight of the ten science teachers offered insight into the impact of a student's immigration generation, although most of their comments did not specifically deal with science aspirations. Rather, their comments tended to relate students' generation of immigration to their more general attitudes towards school and school science. For example, all ten of the teachers thought that their first-generation students were more determined to succeed in school than later generation students. When asked to expand on their thoughts, most teachers focused on

the opportunities available to these students in the U.S., relative to their home countries. For example, CD explained "it's because the first-generation has been experiencing the old country. I had little kids who were living in cardboard cities before they came here. They were the hardest-working, most-polite kids you ever met in your life".

The attitudes of students' belonging to later generations of immigration were different, the teachers explained. Second-generation students were characterized by teachers as less motivated and rather complacent. For example, JM commented "The students who have been here, you know, generations along? They tend to become a little more relaxed or lazy at learning, I would say". Several teachers thought that second-generation students were less motivated in school than first-generation students because they were "comfortable with their life" (FO). For instance, FO described his later generation students as "more complacent, a lot of the times. They're more... motivated by other things".

Interestingly, several teachers thought that, rather than the first-generation, the generation that *should* be the most motivated and successful in school was the third-generation. JW noted:

> First-generation children…it goes beyond the children towards the parents and their attitude. The parents struggle to survive, to meet basic human needs – food, clothing, shelter – that kind of thing. Second-generation not so much. Third-generation, that is the generation I actually find excels in school and, by extension, in science. Other disciplines as well. (JW)

The view that first-generation students were at a disadvantage compared to later generations was supported by BK: "It takes a couple generations for them to start to think that 'Okay. I can participate in this system and I can go to university'. I don't think the first- or second-generation...that's a hard thing to expect".

7.4.7 SES – "You know when I was a kid, I didn't know we were poor"

The effect of the socioeconomic status measure on *Aspirations in science* (*Ais*) differed by grade level. Whereas the SES measure was not found to be related to 6th grade *Aspirations in science*, the SES variable predicted a higher *Ais* score for the highest two SES quintiles (compared to the lower quintiles) for the 9th grade sample – a result most teachers did not find

surprising. The teachers provided two useful and interesting perspectives on their students' socioeconomic status and science aspirations.

First, several teachers suggested an intriguing explanation for the differences in the SES variable's effect depending on grade level. Specifically, three of the teachers thought that it was the maturity level of the 6th grade students (age 11 to 12 years) that limited the SES measure's effectiveness in predicting *Ais*. That is to say, the teachers explained that the 6th grade students were not fully aware of the impact that living in a (very) low socioeconomic area had on their life choices and chances. FO encapsulated this line of reasoning with the adage "You know when I was a kid, I didn't know we were poor". On the other hand, the teachers' found that the 9th graders were well aware of their family's (relatively low) socioeconomic status – and its potential to adversely affect their future. For example, FO, who had taught at both 6th and 9th grade levels, noted that the 9th grade students' "social scene is expanding and they're realizing more of how the world is". In other words, the older students maturing awareness about their life conditions acted to lower their science aspirations.

A different explanation for the relation between grade level, socioeconomic status, and science aspirations was proposed by JW, a thirty-year veteran science teacher of both 6th and 9th grade students in East LA. He suggested that it was the number of dropouts that occurred between 6th and 9th grade that produced the differing SES effect on *Ais*:

> I have a number of conflicting thoughts. And I can't get out of my mind the idea that a lot of kids will have dropped out of school. That's going to influence the success rate. By the time they get to tenth grade the ones that are going to drop out mostly have already dropped out. Rarely in 12th grade. But it makes no sense to drop out of 12th grade. I wonder how much that might skew your findings, but I couldn't get it out of my mind. (JW)

However, JW concluded his thoughts on socioeconomic status with the statement "I have found that the more affluent a student is, the more the parents are involved in their education". This last observation aligns well with the second interesting perspective teachers provided on SES and *Ais*: higher socioeconomic status has a positive influence on science aspirations.

Specifically, when asked how SES might impact their students' science aspirations and education, three teachers pointed out that higher SES parents would likely be "well-educated" (JM). In turn, "well-educated" parents would be more likely to, for example, help with homework, assist with science projects, and provide tutoring. A further advantage of having "well-educated" parents was linked by teachers to home language use: JM explained that "families who have the education tend to use a harder… more difficult language… and they're [the children] exposed to it more often. And so, with that they can understand it [academic language] a little bit better". In other words, the "educated" language used in higher socioeconomic students' homes aligns well with the "academic" language utilized in the science classroom. The connection between language use and SES can be illuminated further by examining the theme that connects all the categories analysed in this section: the subculture of East Los Angeles.

7.4.8 Theme of East LA subculture

Several of the codes in this analysis could reasonably have been located in other categories – suggesting some conceptual overlap between the categories. For example, the code "Math as a barrier" (see Figure A8.1) could have been placed into the category *SES – "You know when I was a kid, I didn't know we were poor"*; the role SES plays in a parent's ability to provide math tutoring was brought up frequently in the interviews. In the final analysis, the code was located in *Language use – Math as a third language* because the idea of learning the "math language" at the same time as learning the English language applied to more students in the study than the fraction of students seeking math help. Nonetheless, it must be realized that both the home language use and socioeconomic status of these students are sociocultural aspects of the neighbourhoods the students live in – East Los Angeles. Accordingly, both categories were located within the general theme that emerged from the analysis of the interview data: **East LA subculture**[50].

[50] Subculture is defined as a cultural group within a larger culture, often having beliefs or interests at variance with those of the larger culture (Oxford Dictionaries, 2010).

The relation between the theme of **East LA subculture**, the categories of teacher interview responses, and science aspirations is diagrammed in Figure 7.1. As shown in the figure, the theme of **East LA subculture** subsumes the seven categories of responses found in the data analysis of the teacher interview data. The four background categories (i.e., *Gender*, *Generation of immigration*, *Language use*, and *SES*) within the theme are seen to influence science aspirations both directly and indirectly, acting together and through the attitudinal components. For example, the categories *Generation of immigration* and *Gender* are connected by the strong gender roles of boys and girls that typically occur within first- and second-generation Latino families. In turn, *Generation of immigration* and *Gender* are both linked to *Family attitudes to science*, which was consistently cited by teachers as an important determinant of these students' science aspirations.

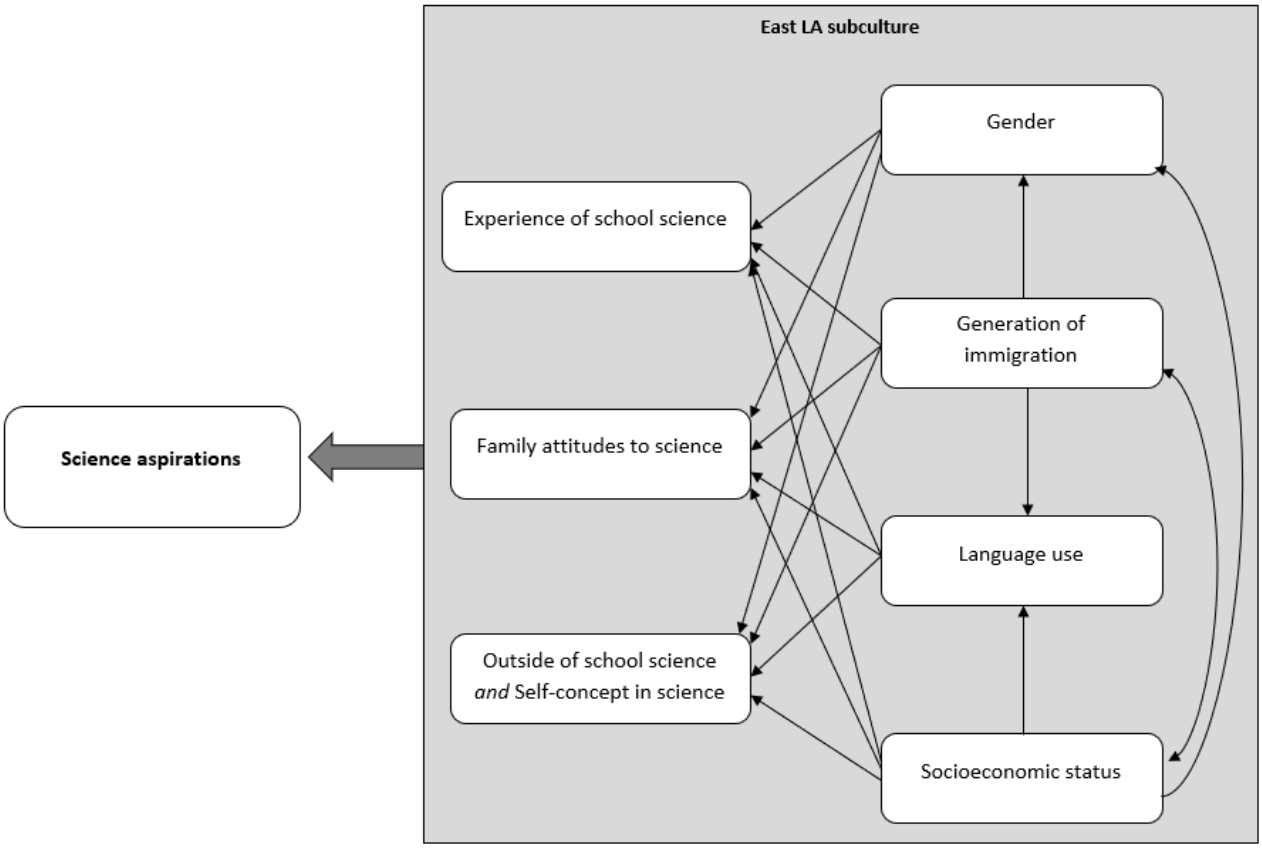

Figure 7.1. Theme and category relations from teacher interviews.

At this point it is worth recalling that certain differences in outcomes by grade levels (6th vs. 9th) were thought by some teachers to result directly from neighbourhood effects. For example, the differing effect of socioeconomic effect on science aspirations between grades was understood by teachers to be the result of older students having become more aware their neighbourhood's effects on their life chances. This finding highlights East LA subculture's profound and persistent influence on the science aspirations of the students in this study.

7.5 Summary of the Teacher Interviews

This chapter presented the methods, data analysis, and findings of the member checking interviews of ten teachers who participated in the main study; the interviews were conducted in order to gain teachers' understandings of the results of the three previous data chapters. Data analysis coded interview transcripts into seven categories of responses related to science aspirations: four corresponding to student background characteristics and three corresponding to attitudinal constructs. The seven categories of teacher responses were shown to be connected and consequently organized into one encompassing theme: East LA subculture. The theme's influence on science aspirations is discussed in relation to the literature next, in Chapter 8.

CHAPTER 8 DISCUSSION

8.1 Introduction

This chapter fuses the four analytic chapters and the literature review in the discussion of the key results, findings, and contributions of this research. This chapter begins by presenting a summary of the study. Next, the results and findings of the research are discussed and interpreted in the light of relevant literature. Last, this study's contributions to knowledge are detailed.

8.2 Summary of research results and findings

Chapter 1 of this thesis detailed the motivation for this study: the underparticipation of U.S. Latinos in the sciences post-secondary school. With the understanding provided by Chapter 1, this study was designed as a systematic investigation of the science aspirations of Latino youth in East Los Angeles, California. The literature reviewed in Chapter 2 highlighted Latino underrepresentation in the sciences and other STEM fields in the U.S. post-secondary level; the literature suggested that science-related attitudes held in secondary school years are significantly linked to aspirations to enter into the science career "pipeline". The link between attitudes and aspirations was explicated utilizing Koballa's (1988) framework, linking science attitudes and related concepts to an observable science-related outcome. The literature reviewed suggested that science-related attitudes change during secondary school, declining over middle and high school years. Studies examining factors theorized to be associated with science-related aspirations and attitudes were reviewed.

The literature on Latino aspirations in science was found to be limited and inconclusive with respect to several important questions within the science aspirations discourse; as well, no study specifically comparing Latino science aspirations in middle and high school appeared to have been carried out to date. Consequently, this study was designed to answer five questions:

1. What are the science aspirations of 6th grade (age 11 to 12) Latino students in East Los Angeles?
2. What are the science aspirations of 9th grade (age 14 to 15) Latino students in East Los Angeles?

3. Which attitudinal factors predict the strength of science aspirations in the two samples? In particular, what is the role of student engagement in science-related activities outside of school, experiences of school science, family attitudes to science, images of scientists, peer attitudes to science, and science self-concept?

4. What are the associations between science aspirations and gender, generation of immigration, home language use, and socioeconomic status?

5. Are there (cross-sectional) differences in science aspirations between the 6th and 9th grade samples?

The existing literature suggested that studies into STEM field participation should account for social, cultural, and economic circumstances specific to the context of the study. Accordingly, this study applied a sociocultural perspective to science education, viewing science education as human social activities conducted within institutional and cultural frameworks (see Lemke, 2001). This perspective highlights (1) Latino's low positioning in the ethnoracial hierarchy of the U.S. and (2) the reproduction of existing inequalities in society through the education system. Latinos' location in the ethnoracial hierarchy is theorized to be accompanied by negative stereotypes and lower expectations throughout all spheres of society, including science education. In terms of societal reproduction, the idea that one source of reproduction stems from a family's *habitus* and science capital (see Archer et al., 2012, 2015) was argued and employed in the current study, for example, to understand family influences on children's science aspirations.

Chapter 3 of this thesis outlined this study's research methods, undertaken in inclusive public secondary schools located in East Los Angeles, CA. The survey instruments utilized to gather the data necessary to explore science aspirations and theorized covariates among Latino secondary school students were examined. The pilot study carried out to test the use of the survey instruments in East Los Angeles was detailed.

In Chapter 4, the principal components analyses carried out to identify science-related constructs within the survey data was presented; the analyses showed the structures of the 6th and 9th grade samples' aspirational and attitudinal components were closely aligned. For

example, comparisons between age groups showed that attitudes towards school science were quite positive while science aspirations were low. The generation of student background measures was described. Analysis of the background variables showed, for instance, significant differences in 9th grade science aspirations by gender.

In Chapter 5, multivariate regression analyses indicated that family attitudes to science and experiences of school science were among the strongest predictors of science aspirations for both the middle and high school samples. In Chapter 6, comparisons and contrasts between samples demonstrated a dip in aspirations between the ages of 11 to 14, which varied by gender and social background. In Chapter 7, analysis of member check interviews with teachers participating in the study suggested that the subculture of East Los Angeles strongly influenced students' science-related attitudes and aspirations.

The following sections detail the important outcomes, patterns, and relations that emerged from the main results (see Chapters 4 to 6) and, utilizing the literature reviewed (see Chapter 2) together with insight gained from the teacher interviews (see Chapter 7), places them in perspective. While the results in many cases confirm expectations from the literature, it must be emphasized that this was the first study to have empirically explored the science aspirations of Latino students in East Los Angeles. Thus, the results provide a unique understanding of science aspirations and its covariates in this context, advancing and contributing to knowledge in science education. The foci of the following sections are on contributions to gaps in knowledge emerging from the results of this research pertaining to (1) Latino science aspirations and science-related attitudes not previously addressed in the literature and (2) theoretical developments in knowledge about science aspirations and attitudes.

8.3 Discussion of principal empirical results (Conclusions about Research Questions)

The overarching aim of this research was to contribute to the understanding of how science aspirations in secondary school could impact Latino participation in science post-secondary school. Specifically, this study extended and added to knowledge in science education by exploring the science aspirations and science-related attitudes of an important demographic in California: Latino youth. More specifically, this research provided an in-depth exploration of

the science aspirations and attitudes of 539 middle school (age 11 to 12) and 428 high school (age 14 to 15) students who lived and attended school in the socioeconomically disadvantaged neighbourhoods of East Los Angeles in 2015-2016. The research questions posed by this study were answered by its results and findings. However, the five research questions were linked, designed to be evaluated together in order to best understand the science aspirations of the students participating in this study. That is to say, a fuller understanding of these students' science aspirations, as well as the influences upon them, was gained from the answers to each successive research question discussed below.

8.3.1 Science aspirations of the 6th grade sample

The first research question asked about the science aspirations of 6th grade Latino students in East Los Angeles. The results of this study suggest that most of these middle school students held no greater than neutral[51] *Aspirations in science*, albeit with some interest in studying science in the future (see Chapter 4)[52]. These results are consistent with other studies examining the science aspirations of students at this age (11- to 12-years-old), although little of the previous research examined Latino science aspirations specifically. Generally, these studies found that few students held high science aspirations at this age (e.g., Aschbacher et al., 2014; Bennett & Hogarth, 2009; DeWitt et al., 2011, 2013; George, 2006; Potvin & Hasni, 2014). For example, the current study's results are quite similar to the findings of Aschbacher et al.'s (2014) study located in Southern California, where they found that the vast majority of middle school students in their study (including some Latino students) did not express strong interest in a future STEM career.

As another example, DeWitt et al. (2011, 2013) found some interest in studying science in the future, together with relatively low aspirations for a career in science, in their study of the science aspirations of 10- to 11-year-olds in the U.K. As the current study shared many of the

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[51] Neutral in this case refers to the scale, when summed from items scored 1-5, having a mean score of 3 – corresponding to an item response of 'neither agree nor disagree'.

[52] It is interesting to note that the results of this study predicted Latino 6th grade students to hold significantly higher science aspirations than White 6th grade students in nearby schools, although the effect size was small (see Appendix 7). This result, occurring 25 years later, resonates with Mickelson's (1990) research with minority groups (Black youth) in Los Angeles.

same survey items as the DeWitt et al. (2011, 2013) study, direct comparisons of response patterns to several items comprising the *Aspirations in science* construct can be carried out. Figure 8.1 displays the combined percentage of agree or strongly agree responses for three survey items included in the *Aspirations in science* construct by both studies. Note that the 6th grade East LA sample response patterns were quite similar to those of the DeWitt et al. (2011) study, albeit with consistently lower positive response rates. For instance, DeWitt et al. (2011) found nearly 50% of students agreed or strongly agreed that they would like to study more science in the future, while about 43% of East LA 6th graders responded similarly. Of the U.K. sample, 33% agreed that they would like to have a job that uses science, compared to 31.2% of the East LA sample[53]. Lastly, 20% of the U.K. students agreed they would like to become a scientist, with 17.1% of East LA students also agreeing with this statement.

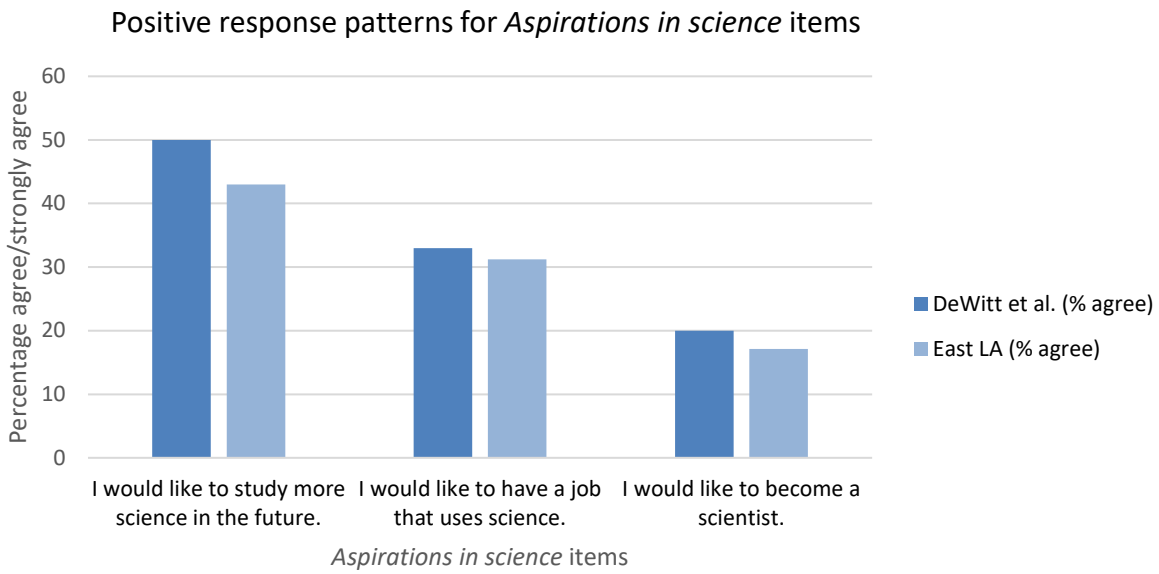

Figure 8.1. Positive response patterns on *Aspirations in science* items for the 6th-East LA and DeWitt et al. (2011) samples.

[53] Bennet & Hogarth (2009) utilized this item as well, and had an 'agree' response percentage of 32% at age 11 – also quite similar to the results of this study.

Note as well that Archer and DeWitt found (at this age) the "majority of students that did not express science aspirations came from working class families" (Archer et al., 2012, p. 900); it is an observation which resonates with the outcomes of the current research located in working-class East Los Angeles. Archer et al. (2012) understood the low science aspirations of the working-class students in their study as a rejection of science as an identity (see Carlone & Johnson, 2007) – the students felt science was "not for me" (Archer et al., 2012, p. 900).

With the lead of Archer et al. (2012), it is useful here to apply Bourdieu's concept of *habitus* as a "structured and structuring structure" (Bourdieu, 1984, p. 170) in understanding these 6th grade students' neutral aspirations towards a future career in science. Specifically, the *habitus* "structuring" a student's science aspirations is considered to be "structured" by family, friends, and neighbourhood influences of East Los Angeles. Consequently, explanations for the neutral science aspirations of the 6th grade sample – tied to the social, economic, and cultural conditions of East Los Angeles – are more appropriately developed in the discussions of the third, fourth, and fifth research questions below.

8.3.2 Science aspirations of the 9th grade sample

The second research question of this study focused on the science aspirations of 9th grade students in East Los Angeles. The results of this research showed that very few of the 14- to 15-year-old students reported an interest in pursuing a career in science – yet, at the same time, most reported interest in studying science in the future. The 9th grade *Aspirations in science* scores were patterned by gender, with boys holding significantly higher science aspirations than girls overall.

This study's results are aligned with the findings a number of recent studies in both the U.S. and U.K. involving high school students' science aspirations (e.g., Barmby et al., 2008; Bennett et al., 2009; DeWitt et al., 2015; George, 2006; Gilmartin et al., 2006; Potvin et al., 2014; Riegle-Crumb et al., 2011). For instance, DeWitt et al. (2015) also found low science aspirations among Year 9 students in their U.K. study. As another example, Gilmartin et al. (2006) explored science-related aspirations in several multiethnic high schools in Southern California. Similar to the results of the current research, they found that the majority of

Latinos in their study (mainly classified as low socioeconomic status) were not interested in a Physical Science/Engineering career; however, it must be pointed out that this was true for every ethnic group in their study except Asian.

The findings of the member check teacher interviews indicated that it was unrealistic to expect these students to hold anything but low aspirations in science, given the layers of disadvantage placed upon them (see Chapter 7). This is an important point to make, as these students' science aspirations did not appear to be impacted by any school standard or prerequisite – these 9th grade students were just starting high school. Rather, the teachers thought that their students' science aspirations were strongly influenced by their perceptions of science, shaped by the conditions of East Los Angeles. This line of reasoning suggests an explanation for the gender difference in 9th grade science aspirations, developed in the discussions of the remaining three research questions below.

It is worth discussing now one of the items that was part of the *Aspirations in science* construct: 'q 11b I would like to study more science in the future'. As noted in Chapter 4, the response pattern for this item was significantly (positively) different from the rather negative response patterns elicited by the other *Aspiration in science* items. Bourdieu's concept of "illusio"[54] offers a way of understanding those students in East Los Angeles who, while wanting to study more science in the future, generally viewed science as an unrealistic future. Specifically, it is likely these students believe in the "value" of learning science – the "illusio" of science – even if they are aware that science has not historically included people like them.

8.3.3 Factors predicting the strength of science aspirations

The third research question sought to determine which of the science-related attitudinal constructs emerging from the principal components analysis significantly predicted the strength of science aspirations in the 6th and 9th grade East Los Angeles samples. Organized by Koballa's (1988) framework, these constructs were theorized to capture attitudes that

[54] Bourdieu (2004) defines "illusio" as "the belief not only in the stakes, but also in the game itself, the idea that the game is worth … playing" (p. 50).

influenced science aspirations – which in turn influenced science-related behaviours (see Section 2.5.1). The results of this study showed that six constructs were significant predictors of 6th grade science aspirations and, as a block, were by far the most important predictors of *Aspirations in science*, accounting for 59.6% of the variation in scores. In order of importance they were: *Experience of school science*, *Family attitudes to science*, *Image of scientist-negative*, *Image of scientist-positive*, *Outside of school science*, and *Self-concept in science*. The five constructs that were significant predictors of 9th grade *Aspirations in science* were *Family attitudes to science*, *Self-concept in science*, *Experience of school science*, *Peer attitudes to science*, and *Outside of school science*. Together, these five constructs accounted for 38.5% of the variance in 9th grade *Aspirations in science* scores.

These results are consistent with a large body of qualitative and quantitative research into factors that influence science aspirations, particularly with respect to future career choices. For example, many other studies have found that the choice to pursue a career in science can be impacted by school science experiences (Aschbacher et al., 2010, 2014; Cleaves, 2005; DeWitt et al., 2011, 2013, 2014; Gilmartin et al., 2006; Lyons, 2006; Riegle-Crumb et al., 2011; Sjøberg & Schreiner, 2005) and by family influences (Archer et al., 2013; Aschbacher et al., 2010; DeWitt et al., 2011, 2013, 2014; Gilmartin et al., 2006; Ing & Nyland-Gibson, 2013) which in turn can influence a student's self-concept in science (Baker, 2005; Beghetto, 2007; Cleaves, 2005; DeWitt et al., 2011, 2013, 2014; Gilmartin et al., 2006; Riegle-Crumb et al., 2011). The similarity of this study's results to so much previous research, in a variety of contexts, bolsters confidence in these measures as important predictors of science aspirations. For example, this study's results align very well with DeWitt et al. (2011, 2013), who in the U.K. found that the factors most closely related to science aspirations for the Y6 students in their study were parental attitudes to science, self-concept in science, interest in science outside of school, experience of school science, and positive image of scientists. As well, DeWitt et al. (2015) found that the factors most closely related to Y9 aspirations in science for the students in their study were parental attitudes to science, attitudes to school science, self-concept in science, and participation in science related activities (outside of school science). Each of these attitudinal constructs is discussed in depth below.

8.3.3.1 Experience of school science

This study found that the 6th grade sample's reported experience of school science was positive (see Section 4.2) and that it was by far the best predictor of their science aspirations (see Section 5.2). These results align well with the findings of much qualitative (e.g., Aschbacher et al., 2010; Cleaves, 2005; Lyons, 2006) and quantitative (e.g., Aschbacher et al., 2014; Barmby et al., 2008; Bennett & Hogarth, 2009; DeWitt et al., 2011, 2013, 2014; George, 2006; Gilmartin et al., 2006; Riegle-Crumb et al., 2011; Sjøberg & Schreiner, 2005) research into the impact of school science experiences on science aspirations. For example, the current study's results are in close agreement with the work of DeWitt et al. (2011, 2013) in the U.K. finding that Y6 students' attitudes toward school science were positive and that the experience of school science construct significantly predicted science aspirations. These results are also consistent with the findings of Aschbacher et al. (2014) in Southern California, which highlighted the effect school science experiences had on science aspirations for middle school students with background characteristics similar to the East LA sample. Specifically, Aschbacher et al. (2014) suggested that the outsized impact of school science on such students was the outcome of having few opportunities to interact with science outside of school. As a result, they point out, they are "particularly vulnerable to poor school science experiences" (p. 741).

The results of the current research showed that the 9th grade sample's experience of school science was positive (see Section 4.3) and that it was a significant predictor of science aspirations (see Section 5.3). These results are similar to the findings of DeWitt et al. (2015) in the U.K., but different from those of Gilmartin et al. (2006) who, in Southern California, found that science class variables did not significantly predict interest in a STEM career. However, it must be pointed out that the school science measure differed between studies. The school science constructs used by Gilmartin et al. (2006) were generally aimed at measuring aspects of school science pertaining to teacher effects and student engagement, sharing just one item in common with the current study: 'My teacher expects me to do well in science'. On the other hand, the DeWitt et al. (2015) measure was much more closely aligned with the current study, sharing five of six constituent items.

One possible explanation for the strong influence of school science experiences on science aspirations in the current study was suggested in the teacher interviews: the lack of authentic experiences with science outside of school. This explanation is supported by the results of Section 4.2, which details these students' very low participation rate in science activities outside of school time. In other words, school science might be many of these students' only experience with science, an explanation which aligns well with the view of Aschbacher et al. (2014).

8.3.3.2 Family attitudes to science

This research found that, overall, the 6th grade students reported their family attitudes to science to be neutral, neither positive nor negative with a mean of 3.53 (SD = 0.86) out of five (see Section 4.2). This result is consistent with the findings of DeWitt et al. (2011), who created a parental attitude to science construct with a mean of 3.63 ($SD \approx 0.86$) using the same three survey items utilized in the current study. As an example, 36.7% of DeWitt et al.'s Y6 sample agreed or strongly agreed with the statement 'My parent would be happy if I became a scientist when I grow up', while 38.1 % of the 6th grade sample responded similarly in this research.

This study found that variation of reported family attitudes towards science to be the second-best predictor of the 6th grade students' science aspirations (see Section 5.2). This result is consistent with the literature researching family and science aspirations, in a variety of contexts (Adamuti-Trache & Andres, 2008; Archer et al., 2010, 2012; Aschbacher et al., 2010, 2014; Dabney et al., 2012; Gilmartin et al., 2006; Ing & Nyland-Gibson, 2013). Note that DeWitt et al. (2011) found parental attitudes to be the strongest predictor of aspirations in science in Y6. Thus, the current study's results pertaining to family attitudes to science support Archer and DeWitt's (2012) view of the central role family plays in stimulating and developing science aspirations. However, DeWitt and Archer (2015) also point out parental "attitudes do not invariably or directly translate into student aspirations in science" (p. 2184). The consistency of the current study's results with the literature suggests that, while family attitudes were found to be an important influence on the 6th grade samples science aspirations, it is clearly not a result unique to 6th grade Latinos in East LA. It is interesting, however, that

the importance of family in Latino culture was emphasized by many teachers in the member check interviews and, as discussed below, took on increased importance in predicting the science aspirations of the older students in this study.

The results showed that 9th grade family attitudes towards science were neutral overall (see Section 4.3). This outcome was inconsistent with that of DeWitt et al. (2015), who reported positive parental attitudes towards science in their Y9 study of science aspirations and related attitudes. For instance, DeWitt et al. (2015) reported that over 70% of the students in their study agreed or strongly agreed with the statement 'My family think it is important for me to learn science' (p. 2182), while only about 40 % of the students in the current study agreed with the same statement. One explanation for the neutral family attitudes towards science found in the current study was suggested in the teacher interviews. Specifically, one teacher pointed out that "literally nothing in their lives revolves around science" – a straightforward evaluation of these students' low science capital (see Archer et al., 2015).

The results indicate that the best predictor of 9th grade science aspirations was family attitudes to science (see Section 5.3). This result is consistent with much previous research that has found students' family relation with science to be very influential on science aspirations at this age (e.g., Aschbacher et al., 2010; Dabney et al., 2012; DeWitt et al., 2015; Gilmartin et al., 2006; Ing & Nyland-Gibson, 2013), particularly for Latino students (Gilmartin et al., 2006). For example, DeWitt et al. (2015) found parental attitudes to be the strongest predictor of science aspirations for Y9 students in their U.K. study. This result also accords with Gilmartin et al. (2006), who found in the Southern California context that family science orientation was strongly related to interest in a science career for the high school students in their study. Further, the effect of the family science predictor was found to be stronger for Latino students in comparison to the Black and White students in their study (Gilmartin et al., 2006).

A possible explanation for the strong influence of family on Latino science aspirations, emerging from the teacher interviews, was that in Latino culture "family is all". If this is the case, the observation made by one teacher – that most of their students' families did not see science as a "future" for their children – is particularly noteworthy. That is to say, if the family

message is that science is not a realistic career path for their children, then that message would be that much stronger in a Latino family. When seen from this perspective, it is understandable that only about a third of these students thought their families would be happy if they became scientists and even fewer thought science was of any interest to their family.

Interpreting this result with respect to *family habitus* (Archer et al., 2012) suggests that that a family's low interest in science acts to limit the "science capital" (Archer et al., 2015) accrued by that family. In turn, limited "science capital" would negatively impact science aspirations, as "science capital" is theorized to stimulate, support, and maintain interest in science (Archer et al., 2015).

8.3.3.3 Image of scientists

This study found that the 6th grade students' images of scientists were very positive (see Section 4.2) and to be the third-best predictor of their science aspirations (see Section 5.2). These results are in agreement with the findings of a great deal of previous work into how perceptions of scientists influence decisions to pursue science-related careers in the future, where positive images influence decisions in a positive way (e.g., Baker, 2005; Bennett & Hogarth, 2009; Calabrese Barton & Yang, 2000; Cleaves, 2005; DeWitt et al., 2011; Miller et al., 2006). However, this outcome is unlike the findings of DeWitt et al. (2013), who at this age did not find an association between images of scientists and aspirations in science. While DeWitt et al. (2013) suggest that this could be due to the limitations of their survey instrument, note that the same instrument was used in the current study. It is possible that this inconsistency in results is due to factors underpinning the positive images of scientists. For example, in the case of the 6th grade students in East LA, it was suggested by some teachers that their students' positive image of scientists was a result of the positive portrayal of scientists in the media. More specifically, teachers pointed out that crime scene investigation television programs featuring scientists were quite popular among their students. However, as the items underpinning this construct were not discussed in the DeWitt et al. (2011, 2013) papers, more specific comparisons cannot be carried out.

8.3.3.4 Outside of school science

This study found that 6th grade students' participation in science related activities outside of school was a significant predictor of their science aspirations (see Section 5.2). These results align with the findings of Dabney et al. (2012), who in the U.S. context found that participation in science activities during middle school years played a significant role in students' career interest in STEM during university years. These results are also similar to DeWitt et al.'s (2011) research in the U.K., who found that students' interest in science outside of school predicted science aspirations for students at this age.

At the same time, the current study found that participation in science-related activities outside of school was extremely limited for these 6th grade students (see Section 4.2). This result is consistent with, for example, Bennett and Hogarth (2009) who found low participation rates in science outside of school in their U.K. study. In their research based in California, Aschbacher et al. (2010, 2014) observed that participation in science-related activities outside of school was partially a function of socioeconomic status. As a result, students from homes with limited resources had few opportunities to interact with science outside of school. The findings of the member check interview lend support for Aschbacher et al.'s (2010, 2014) observation; several teachers pointed out that children from East Los Angeles were unlikely to interact with science outside of school due to the socioeconomic conditions of the area.

This study found that 9th grade participation in science activities outside of school were a significant predictor of science aspirations (see Section 5.3) and to be limited to about once a year, at most (see Section 4.3). As these 9th grade results are quite similar to that of the 6th grade sample, further discussion of this component was located in the sample comparisons discussion later in this section.

These results broadly support the work of Bourdieu, whose research suggested that participation in certain cultural practices (such as visiting science museums) reinforce the distinctions between economic class and culture, which in turn reproduces social disadvantage (Bourdieu, 1984). More specifically, these students' societal position and the structure of the

field of outside of school science constrained their participation in activities which supply cultural "science capital" – capital theorized to provide advantage in science-related fields and stimulate science aspirations (Archer et al., 2015). For example, the current study found that these students' participation in outside of school activities, such as science museum visits, was very limited and patterned by structured factors (i.e., gender and socioeconomic status). As well, the analysis of the teacher interviews suggested that these students' low rates of participation in science outside of school were the outcome of structural constraints characteristic of East Los Angeles (e.g., low socioeconomic status). Thus, the interaction between participation in science outside of school, socioeconomic status, and science aspirations can be understood to play a role in the reproduction of social inequalities.

8.3.3.5 Peer attitudes to science

This study found that the 9th grade *Peer attitudes to science* were a significant predictor of *Aspiration in science* (see Section 5.3). This outcome is inconsistent with the U.K. findings of DeWitt et al. (2013, 2014, 2015), who did not find this construct to be a significant predictor of aspirations in science; they suggested that the effects of peer attitudes on science aspirations were indirect and that perhaps most students "may not be aware of its influence on them" (DeWitt et al., 2013, p. 1054). On the other hand, these results generally align with the findings of Breakwell and Beardsell (1992) in the U.K., as well as with Robnett and Leaper (2012), George (2006), and Talton and Simpson (1985) in the U.S. These studies all found peer influences to be significantly associated with science attitudes. Note that Talton and Simpson (1985) found that the influence of peer groups peaked in 9th grade and this point will be expanded upon later in this section, in the discussion of the sample comparisons.

8.3.3.6 Self-concept in science

This research found that the 6th grade students' reported self-concept in science to be neither positive nor negative overall (see Section 4.2). This result is consistent with some previous studies involving science self-concept (e.g., Aschbacher et al., 2010, 2014; Cleaves, 2005; Gilmartin et al., 2006) that have found less than positive science self-concepts, particularly

among Latino students (Beghetto, 2007; Riegle-Crumb et al., 2011)[55]. On the other hand, this result is somewhat different the work of DeWitt et al. (2011), who found most Y6 students in their study reported a "fairly positive self-concept in science" (p. 259).

In the case of the Aschbacher et al. (2014) study it is possible to directly compare the response pattern of one survey item used to measure self-concept in science in order to secure a deeper understanding of the construct. Specifically, just 16% of the middle school students in the current study strongly agreed with the statement 'I learn things quickly in science class', while 19% of the middle school students in the study by Aschbacher et al. (2014) also strongly agreed – a remarkably similar outcome. The similar response pattern across studies suggests that school science experiences could be an important influence on students' self-concept in science. However, it is also important to recognize that the relation between self-concept in science and experience of school science is likely reciprocal for these students and this was not investigated in the current study.

The results of this study showed that 6th grade students' self-concept in science was a significant predictor of their science aspirations (see Section 5.2). This result supports the outcomes of a large body of research finding children's beliefs about their own self-concept in science to be a useful and valid predictor of their aspirations (Aschbacher et al., 2010, 2014; Calabrese Barton et al., 2008; Cleaves, 2005; DeWitt et al., 2011, 2013; Gilmartin et al., 2006; Riegle-Crumb et al., 2011; Schoon, 2001). For example, in the U.K., DeWitt at al. (2011) found that self-concept in science was the third best predictor of aspirations in science (of five) in their Y6 sample. In the U.S., the results also align with Aschbacher et al. (2014), who in Southern California found science self-perceptions to be significantly related to science career interest in middle school.

[55] Interestingly, Beghetto (2005) found that boys on average had more favourable perceptions of their science self-concept than did girls. By comparison, the current study did not find significant differences in self-concept scores by gender, although 6th grade boys did hold a slightly higher mean score (M = 3.53, SD = 0.73) than 6th grade girls (M = 3.48, SD = 0.80).

The results showed the 9th grade samples self-concept in science to be neutral overall (see Section 4.3). The results showed that the second strongest predictor of 9th grade aspirations in science was self-concept in science (see Section 5.3). These results are consistent with other studies examining the effects of science self-concept on science aspirations at this age in a variety of contexts (e.g., Aschbacher et al., 2010; Calabrese Barton et al., 2008; DeWitt et al., 2015; Gilmartin et al., 2006; Riegle-Crumb et al., 2011; Schoon, 2001). For example, in the U.K. DeWitt et al. (2015) found self-concept in science to have the third strongest relation (after parental attitudes and attitudes to school science) with aspirations in science in their study of Y9 students. In the Southern California context, Gilmartin et al. (2006) found a positive self-concept at this age to be by far the strongest predictor of career interest in the physical sciences and engineering.

8.3.3.7 Summary of the discussion of Research Question 3

The results discussed to this point are quite consistent with previous research. The discussion of the factors associated with 6th and 9th grade aspirations in science highlighted the importance of family, peers, and school in shaping these student's science aspirations. While other research into science aspirations at these ages (11 to 14) have noted, for example, the influence of family and school science, the results and findings of the current study suggest that the strength of these influences are related to the context of this study. Accordingly, the fourth research question seeks to evaluate contextual effects on these students' science aspirations.

8.3.4 Student characteristics and their associations with science aspirations

The fourth research question of this study examined four student characteristics theorized to be associated with science aspirations: gender, generation of immigration, home language use, and socioeconomic status. As detailed in the literature review, previous research has linked these four background characteristics to science-related achievement, aspirations, attitudes, and participation. For instance, many studies have found that science aspirations and attitudes are structured by gender and socioeconomic status (e.g., Aschbacher et al., 2010; DeWitt et al., 2014; Gilmartin et al., 2006), while other research has shown science-related attitudes are

associated with generation of immigration (e.g., Crisp et al., 2009) and home language use (e.g., Lee, 2005).

Overall, the results of this study showed that, although there were group differences in science aspirations among the four student background characteristics, only home language use and socioeconomic status significantly predicted 6th grade aspirations in science; no background variable significantly predicted 9th grade science aspirations in the final regression model. As there was limited variation within the 6th grade *Aspirations in science* and background variables, these results must be interpreted with caution and this is discussed below for the relevant background characteristic.

8.3.4.1 Gender

The results of this study revealed a significant gap in *Aspirations in science* scores by gender within the 9th grade sample, with boys reporting higher science aspirations than girls, a small but meaningful effect (see Section 4.5). This result is consistent with the findings of a great deal of previous work examining gender differences in science-related attitudes and aspirations at this age (e.g., Bennett & Hogarth, 2009; Dabney et al., 2012; DeWitt et al., 2015; Maltese & Tai, 2010), as well as several studies that included students from Latino backgrounds (Aschbacher et al., 2010; Gilmartin et al., 2006; Riegle-Crumb et al., 2011). For example, in the U.K. DeWitt et al. (2014) found gender to be closely associated with aspirations in science at Y9 – and that it was a negative association for girls. In Southern California, Gilmartin et al. (2006) found boys were more likely than girls to express interest in a science related career in high school; they suggested that girl's science aspirations were influenced by ethnic role models and family members more so than boys at this age. The current study's results are also consistent with the qualitative work by Aschbacher et al. (2010) in Southern California, where they found cultural pressures on Latina (female) students acted to reduce their science aspirations in high school. The idea of Latino culture acting to reduce science aspirations among Latino girls is supported by the analysis of the teacher interviews; several teachers recounted experiences illustrating the (negative) effect of Latino culture on girls' science aspirations.

While there was a significant gap in science aspiration scores by gender in the 9th grade sample, the results indicated that gender was not a significant predictor of *Aspirations in science* for either the 6th grade sample (see Section 5.2) or the 9th grade sample (see Section 5.3). These findings are consistent with Aschbacher et al. (2014), who did not find a relation between gender and science aspirations at these ages, but inconsistent with DeWitt et al. (2013, 2014) who found differences in aspirations in science by gender at Y6 and Y9 – where girls were predicted to hold lower science aspirations than boys.

Note that in the current study, it is possible that the effect gender had on *Aspirations in science* was mediated by the attitudinal variables (e.g., *Family attitudes to science*, *Experience of school science*) entered into the regression model after the block of background variables. This can be seen in Table 5.8 where the entry of the attitudinal variables reduces the predictive strength of gender on 9th grade *Aspirations in science* by more than half (from $\beta = .088$ to $\beta = .042$). The relation between gender and science aspirations is examined further in the discussion of the sample comparisons, later in this section.

8.3.4.2 Generation of immigration

The results did not find a consistent pattern of association between generation of immigration and science aspirations. That is to say, while first-generation students in the 9th grade sample held significantly higher *Aspirations in science* scores than later immigration generations, no differences were observed for the 6th grade sample (see Section 4.5). Further, while generation of immigration significantly predicted 9th grade aspirations in science initially, it no longer predicted aspirations after attitudinal variables were entered into the regression model (see Sections 5.3).

In Chapter 2 it was suggested that the theory of segmented assimilation (Portes, 1996) could be usefully applied to understand possible differences in science aspirations by immigration generation, while noting that such an application of the theory had not previously been carried

out[56]. In this study, application of the theory predicted that second-generation students in East Los Angeles would undergo downward assimilation, resulting in lower science aspirations (compared to first-generation students). Thus, the higher science aspirations predicted for the 9th grade first-generation students in Model 1, compared to the second- and third-generations, aligns with the theory of segmented assimilation. On the other hand, the 6th grade results – no differences between generations – are not consistent with what would be expected from downward assimilation (lower aspirations in later generations).

Note that the analysis of interview data suggested that generation of immigration did influence science aspirations. More specifically, most teachers indicated that second-generation students should be expected to have the lowest science aspirations of the four generations comprising the variable. In the case of the 9th grade sample, one possible explanation for the contradiction between the survey and interview analyses can be generalized from the discussion of the SES variable (See Appendix 7 and below). That is to say, the influence of background variables on science aspirations were likely mediated through the attitudinal variables.

8.3.4.3 Home language use

The results indicated home language use was a significant predictor of aspirations in science for the 6th grade sample only (see Section 5.2). Specifically, 6th grade students speaking a language other than English at home all the time were predicted to have significantly higher science aspirations compared to students speaking English at home half the time. The same relation was found within the extended 6th grade sample (see Appendix 7). While the literature review did not locate any studies specifically examining home language use and science aspirations, the 6th grade result can be seen to be generally consistent with the U.S. findings of Raleigh and Kao (2010); they found that immigrant Latino parents who maintain Spanish use at home are more likely to hold consistently high academic aspirations for their children than immigrant Latino parents who do not similarly maintain Spanish use at home. That is to say, the higher science aspirations found among the 6th grade students who spoke Spanish at home

[56] A note of caution is due here, as the theory put forth by Portes (1996) was not developed to specifically explain differences in science aspirations by generation of immigration in East Los Angeles – the theory was appropriated by this researcher.

all the time were perhaps the result of higher academic aspirations at home generally. However, caution must be applied to this result, as the two other groups within this variable – speaking a language other than English 'never' and 'once in a while' – were not found to be significantly different from the 'all the time' group; nor was a similar relation found within the 9th grade sample. This difference in results between grades is explored further in the discussion of the sample comparisons, later in this section.

8.3.4.4 Socioeconomic status

The results showed socioeconomic status (SES) was not significantly associated with *Aspirations in science* for either sample in Model 1(background characteristics only) of the regression analysis (see Sections 5.2 and 5.3). However, once attitudinal components were entered into the regression model, 6th grade SES emerged as a significant predictor of *Aspirations in science*. Specifically, the highest 6th grade SES quintile (Q5) was predicted to have lower science aspirations than the lowest quintile (Q1) – the opposite of the expected outcome. That is to say, this result was inconsistent with much previous research on socioeconomic status and science aspirations (e.g., Aschbacher et al., 2010, 2014; Bennett & Hogarth, 2009; Dabney et al., 2012; DeWitt et al., 2013, 2014, 2015; Gilmartin et al., 2006), where higher socioeconomic status was generally associated with higher science aspirations. Consequently, this study's results must be understood and interpreted with caution.

It is thought that this study's unusual results with regard to socioeconomic status and science aspirations are the outcome of (1) the restricted range of the SES variable within the samples and (2) the mediation of the variable's effect by the attitudinal variables. As shown in Appendix 7, the sensitivity of the SES measure was limited by the (restricted) variation within the East LA sample; this was demonstrated by comparison of the East LA sample to a more diverse extended sample. Specifically, SES was a significant predictor of *Aspirations in science* in the 6th-Extended sample, which had a greater range of SES scores (see Appendix 7). Mediation of the SES variable was also observed in the analysis of the 6th-Extended sample. In Model 1 of the regression analysis students belonging to Quintile 5 were predicted to have significantly higher science aspirations, relative to Quintile 1 ($\beta_{Q5_M1} = .15$, $p < .01$).

With the entry of the attitudinal components into the regression, the magnitude of the beta was reduced (β_{Q5_M2} = .01) and lost significance (see Table A7.6).

8.3.4.5 Summary of the discussion of Research Question 4

Taken together, the survey results showed that student background characteristics did not significantly predict these students' science aspirations. Nonetheless, the majority of teachers interviewed expressed strong views about the relevance of the four background characteristics to their students' science aspirations. For instance, there was a clear consensus among the teachers interviewed that primarily speaking Spanish at home and being of low socioeconomic status would act to lower science aspirations; however, the results of the regression analysis were not consistent with this view. It was suggested that the differences between the student survey and teacher interview outcomes were to some extent the result of the mediation of the background variables by the attitudinal variables in the regression analysis. Lastly, there was agreement between the survey results and the interview findings on the effect of 9th grade gender on science aspirations: lower science aspirations for girls. Deeper understanding of this gender-related result is found in the comparisons of the 6th and 9th grade sample analyses, which is discussed next.

8.3.5 6th grade and 9th grade sample comparisons and contrasts

The fifth question in this research study asked about important similarities and differences between the 6th and 9th grade samples' science aspirations. The literature reviewed generally reported a decline, or "dip", in science attitudes between the ages of 11 and 14 (e.g., Barmby et al., 2008; George, 2000, 2006; Osborne et al., 2003; Potvin & Hasni, 2014; Sorge, 2007) which in some cases was structured by background characteristics (e.g., Bennett & Hogarth, 2009). Comparisons and contrasts of the results of the 6th and 9th grade analyses revealed four substantive differences between the two sample results: (1) an overall decline in science aspirations and attitudes with age, (2) the exception to the "dip" trend for school science experiences, (3) the widening of the gender gap in aspirations between the ages of 11 and 14, and (4) the increasing influence of social context on 9th grade science aspirations.

8.3.5.1 Result 1a - Decline in science aspirations between ages 11 and 14

The results of this study showed that the younger students had significantly higher mean scores on the *Aspirations in science* variable relative to the older students, with small but meaningful effect, $d = .30$ (see Chapter 6). This result is consistent with the findings of Bennett & Hogarth (2009), who in the U.K. found a sharp drop in positive responses between the ages of 11 and 14 on one of the items that comprised the *Aspirations in science* construct in the current study: 'I would like to have a job that uses science'. However, this outcome is inconsistent with that of DeWitt et al. (2015), who found in their U.K. study that aspirations in science significantly increased between Y6 and Y9.

DeWitt et al. (2015) linked the increase in science aspirations in their study to increases in the positive response patterns on two of the items making up their aspirations in science construct: 'I would like to have a job that uses science' and 'I would like to study more science in the future'. The current study, however, found a decrease in positive responses across all items that made up the *Aspirations in science* construct from 6th grade to 9th grade (see Chapter 6). As the research of DeWitt et al. (2015) and the current study were carried out in very different contexts, differences in outcomes might be expected. Note, however, that the survey items used in both studies were identical. Consequently, the difference in the two studies' results suggests that it is the context of the current research that accounts for the dip in science aspirations observed across the East LA sample. Indeed, the main theme emerging from the teacher interview data was that it was the overlapping influences of the neighbourhood that primarily shaped these students' science aspirations.

8.3.5.2 Result 1b - Declines in science-related attitudes between ages 11 and 14

The results showed that the decline in science aspiration mean scores was accompanied by drops in nearly every other science-related attitude score measured in this study[57]. Table 8.1 shows a comparison of relative changes in attitudinal measures, between the ages of 11 and 14, for five studies (Barmby et al., 2008; Bennett & Hogarth, 2009; DeWitt et al., 2014, 2015;

[57] With the exception of a significant increase in positive school science experiences, which is discussed following.

George, 2006; Potvin & Hasni, 2014; Sorge, 2007) that utilized similar items within similar attitudinal constructs. An upward arrow in the table indicates a rise in attitude between years 11 to 14, a downward arrow indicates a dip, and an approximately equal symbol indicates maintenance of attitudes[58]. While the variables used in the studies were not precisely equivalent, the constructs included in Table 8.1 were designed to measure the same science-related attitude and shared at least one item with the current study's construct. For example, George (2006) shared one item with this study for *Peer attitudes to science* ('How many of your classmates… like science?'), while DeWitt et al. (2013, 2015) shared two ('How many of your classmates… like science?', 'How many of your classmates… think science is cool?').

[58] This table reflects absolute changes in the magnitudes of the measures listed. Differences in statistical significance and effect sizes between the studies are not accounted for in the table.

Table 8.1. Change in selected science-related attitudinal measures between the ages of 11 and 14 years.

Attitudinal construct	**East LA (2016)**	Barmby et al. (2008)	Bennett et al. (2009)	DeWitt et al. (2015)	George (2006)	Potvin et al. (2014)
Aspirations in science	↓	↓	↓	↑		
Experience of school science	↑	↓	↓	≈	↓	↓
Family attitudes to science	↓			↑		
Image of scientists-positive	≈			≈		
Outside of school science	↓	↓	↓	↓	↓	
Peer attitudes to science	≈			↓	↓	
Self-concept in science	↓	↓		≈	↓	↓

Note: ↑ rise, ↓ dip, ≈ maintained.

In general, there are patterns across studies for the attitudinal elements in the table. For example, every study examining outside of school science (five of six) showed a decline from ages 11 to 14. However, with the exception of outside of school science, the current study's results are in mixed agreement with the literature, often agreeing and disagreeing with different findings from the same study. For example, while DeWitt et al. (2014, 2015) found in the U.K. that student-reported family attitudes to science increased between Y6 and Y9, the current study showed a decrease between the same years. In the U.S., for instance, George (2006) found that students' science aspirations generally declined over middle school and high school years, as well as constructs corresponding to experience of school science, self-concept in science, peer attitudes to science, and outside of school science. The current study found that, while self-concept in science and outside of school science decreased between 6th and 9th grade, experience of school science and peer attitudes to science scores maintained or increased.

Interestingly, while the weight of three of the four studies shown in the table suggest a dip in science aspirations, there was no consensus among the explanations for the dip. For example, while George (2006) suggests that the dip in school science interest is dependent on the type of science instruction (p. 584), Potvin et al. (2014) suggest that it is school itself that produces the observed dip. The decline in science aspirations and attitudes observed across 6th and 9th grade in the current study, together with the exception of school science experiences, suggests that it is factors originating outside of school that drive the "dip" in the East Los Angeles samples. The results of this study support this observation about the origins of the "dip" in the East Los Angeles sample: a number of science-related attitudes and aspirations were found to be structured by student background characteristics (see Chapter 4, Chapter 5, and Appendix 7). As well, the context of this research was consistently cited in the teacher interviews as a powerful influence on the attitudes and aspirations of these students (see Chapter 7).

8.3.5.3 Result 2 - The "dip" exception: Experience of school science

The results indicated that the only science-related attitude score to significantly increase between the 6th and 9th grade samples was *Experience of school science*. This result differs from DeWitt et al. (2015) who, while reporting that students in both Y6 and Y9 enjoyed their

science lessons, found a small decline in school science attitudes across years. This result also differs from Barmby et al. (2008), Bennet et al. (2009), George (2006), and Potvin et al. (2014), who all reported a decline in school science attitudes from ages 11 to 14. One possible explanation for the increase in positive attitudes towards school science in the current study was suggested in the teacher interviews, where several teachers noted that there had been a systematic effort within the schools to make school science more enjoyable for the students.

8.3.5.4 Result 3 - Widening of the gender gap in aspirations between the ages of 11 and 14

The results showed that the dip in science aspirations by age was structured by gender. Specifically, the gap between boys' and girls' aspirations in science increased significantly between the ages of 11 and 14 (see Chapter 6). Table 8.2 displays a comparison of the change in science aspirations between the ages of 11 and 14, by gender, for several studies reviewed in this thesis. The upward pointing arrow signifies an increase in the gap in science aspirations for girls compared to boys between age 11 to 14. The current study's result agrees with Barmby (2008), Bennett et al. (2009), and Potvin et al. (2014), who all found a widening gender gap within the overall decline in science aspirations and attitudes between the ages of 11 and 14; these results indicate female students grew less positively disposed than males towards a future in science. However, this study's result is inconsistent with DeWitt et al. (2015) who found a small *decrease* in the science aspirations gap by gender from Y6 to Y9.

The analysis of the teacher interviews suggests that it is the context of the study that best explains this result. More specifically, the analysis of the teacher interviews details traditional Latino families in East Los Angeles, where girls were expected to assume greater domestic responsibilities within the family as they matured. In turn, greater domestic responsibilities acted to diminish science aspirations.

Table 8.2. Change (Δ) in science aspirations gap by gender between the ages of 11 and 14 years.

Variable	**East LA (2016)**	Bennett et al. (2009)	Barmby (2008)	DeWitt et al. (2014)	Potvin et al. (2014)	Sorge (2007)
Δ in science aspirations gap (gender)	↑	↑	↑	↓	↑	≈

Note: ↑ gap increase**,** ↓ gap decrease, ≈ maintained.

8.3.5.5 Result 4 - The importance of social context among the older students

The results showed that measures related to social contexts gained importance for predicting the older students' science aspirations, relative to the younger students (see Chapter 6). Specifically, the effects on *Aspirations in science* strengthened across the ages of 11 and 14 for *Family attitudes to science* (sr^2_{6th} = .142 to sr^2_{9th} = .204) and *Peer attitudes to science* (sr^2_{6th} = -.034 to sr^2_{9th} = .104). This result is different from DeWitt et al.'s (2015) comparison of Y6 and Y9 science aspirations and attitudes. While DeWitt et al. (2015) found parental attitudes to science to be a significant predictor of aspirations in science for both Y6 and Y9 samples, they found an overall *decrease* in the strength of the relation between these years. As well, peer attitudes to science was not found to be a significant predictor of science aspirations in Y9 (DeWitt et al., 2015). The results of the current study showed an increase in the strength of both of these significant predictors in the 9th grade sample, to the point that *Family attitudes to science* was the strongest predictor of 9th grade *Aspirations in science* overall.

A possible explanation for the greater importance of family and peer influences on the 9th grade students' science aspirations was suggested in the teacher interviews. The teachers felt that the older students had entered into a different stage of thinking about their life chances, in comparison to the younger 6th grade students. For example, it was pointed out in the interviews that there was likely "no one" in their students' neighborhoods involved with science. Rather, family, friends, and neighbors were making a living *not* involving science; as a result, this would tend to influence these students away from envisioning a future in science. The behaviour of the socioeconomic status measure in the regression analysis further strengths the idea that social context had greater influence on the older students' science aspirations, compared to the younger students. The results showed that, within the 9th grade sample, higher socioeconomic status predicted higher science aspirations; the same effect was not seen in the 6th grade sample. The idea of older students' science aspirations being more strongly influenced by social context also finds support from the findings of Talton and Simpson (1985). They note that "individual attitudes toward science become increasingly more like those of the peer group as students progress through middle and junior high school, and that this correlation may reach a peak in the ninth grade" (Talton and Simpson, 1985, p. 23). Note

as well that their work also suggests a partial explanation for the weak association between peer attitudes and science aspirations observed in the current study's 6th grade sample.

It is useful now to examine the results discussed to this point with the perspective provided by Bourdieu's concepts. Bourdieu (1984) held that field and *habitus* interact or, to borrow a physics analogy, resonate[59]. From this point of view, a student's experiences in science (field) are seen as shaping their science-related attitudes (*habitus*), which in turn drives their science-related aspirations and behaviours. However, these students' science-related attitudes are structured by the limitations East Los Angeles places on their science-related experiences. In this way, the low science aspirations found in this study can be interpreted as a type of exclusion from the field of science. Thus, the interplay between attitudes resulting in low science aspirations and an exclusive field of science contributes to the reproduction of disadvantage and social inequality (see Chapter 2). In other words, the resonance effect between students' *habitus* and the structured limitations of East Los Angeles results in the reproduction of social disadvantage in East Los Angeles.

8.3.5.6 Summary of the discussion of Research Question 5

The results of this study showed that there was an overall dip in science aspirations and science-related attitudes between the ages of 11 and 14 in the East Los Angeles samples. Comparisons with similar studies of science aspirations and attitudes, as well as the analysis of the teacher interviews, suggest that it is likely the context of the current study that accounts for the declines. The widening of the gender gap in science aspirations between the ages of 11 and 14 was also linked to the context of this study, East Los Angeles. The increasing influence of social context on 9th grade science aspirations was found to be related to the conditions of East Los Angeles, which act to adversely impact the older students' science aspirations.

Taken together, the results of this study detail a group of students in East Los Angeles whose science aspirations were low in middle school and lower still in high school. At the same time,

[59] According to Young et al. (2014), resonance is "the peaking of the amplitude at driving frequencies close to the natural frequency of the system" (p. 456).

they reported their school science experiences to be quite positive, increasing across the same years. The findings of this study suggest that the Latino culture of East Los Angeles – focusing on family and gender norms – acted to lower these students' science aspirations and attitudes. As well, this study found that the observed dip in science aspirations and attitudes between ages 11 and 14 was linked to the neighbourhood conditions of East Los Angeles. Thus, the results and findings of this study suggest that these students in East Los Angeles exclude science from their vision of their future over time. Science is unrelated to their lives and they, their families, and their friends simply do not participate in it to any meaningful extent outside of school. The contributions to knowledge based upon the results of this study are presented next.

8.4 Contributions to knowledge

8.4.1 Latino science aspirations and science-related attitudes

The main contribution of this research to knowledge is to establish a detailed understanding of the influences on the science aspirations and science-related attitudes of urban Latino students, based on empirical data from East Los Angeles. Useful contextual information for the East Los Angeles sample was provided in the form of an extended 6th grade sample and post-survey teacher interviews. Importantly, the results of this study show that these students' science aspirations, although broadly similar to those found in previous studies of science aspirations (e.g., Aschbacher et al., 2010; DeWitt et al., 2013, 2015; Gilmartin et al., 2006; George, 2006), were shaped by the strength of a unique set of influences. The findings of this study suggest that science aspirations in East Los Angeles were to a great extent structured by the neighbourhood itself, an effect expressed in their science-related attitudes. Consequently, the results and findings from this study contribute to existing knowledge in four key ways.

First, by replicating the substantive findings of DeWitt et al. (2013, 2015) in East Los Angeles, this study demonstrates both the usefulness and efficacy of science-related attitudes in predicting science aspirations. Second, this study contributes to our understanding of the science aspirations of urban Latino students in the U.S., an important but underresearched demographic group. Third, this research provides empirical evidence of influences on Latino

science aspirations and ways in which they are interconnected. Fourth, this study identifies differences between Latino middle school and high school students' science-related attitudes and aspirations.

8.4.1.1 Demonstrating the efficacy of predictors of Latino science aspirations

The four significant predictors of science aspirations common to both samples in this study were family attitudes to science, experience of school science, self-concept in science, and outside of school science. Note that these predictors were generated from a survey instrument based on the ASPIRES instrument developed by DeWitt et al. (2011). DeWitt et al. (2011, 2013, 2015) found the factors most closely related to aspirations in science for the students in their research were parental attitudes to science, attitudes to school science, self-concept in science, and participation in science related activities (outside of school science) – above and beyond any background characteristics applied. Thus, this study's replication of the substantive findings of DeWitt et al. (2011, 2013, 2015) – in a very different context – demonstrates that these constructs measuring science-related attitudes and predicting science aspirations have efficacy, advancing research on student attitudes and aspirations towards science within the field of science education (see Tytler & Osborne, 2012).

8.4.1.2 Establishing a baseline of Latino science aspirations

A variety of factors have been identified as influencing, to greater or lesser extent, the science aspirations of students between the ages of 11 and 14. However, before this study relatively little was known about Latino science aspirations at these ages or factors significantly associated with them. This research highlights the importance of family and school science experiences on Latino students' science aspirations, which in this study ranged from neutral (younger students) to low (older students). Context and support for the 6th grade results were provided through the analysis of an extended sample, which included students attending more diverse schools in neighbourhoods adjacent to East Los Angeles (see Appendix 7); while slightly lower overall, science aspirations were similar across schools. These results contribute to the topic of student attitudes towards science in the field of science education by establishing a baseline with context for future research into the science aspirations of urban

Latinos in Los Angeles County, nearly half the population of a community with over 10 million residents.

8.4.1.3 Providing empirical evidence of influences on Latino science aspirations

This study showed that science aspirations for the older students in this study were patterned by gender, with 9th grade boys holding significantly stronger science aspirations than 9th grade girls; the same pattern was not found within the 6th grade sample. It was suggested in this thesis that these results were an outcome of the structuring effects of the neighbourhoods of East Los Angeles, where boys and girls receive different messages about their future possibilities. This result adds to the body of intersectional research that focuses on the relations between multiple social positions and social inequities in science education (e.g., Aschbacher et al., 2010, 2014; Dewitt et al., 2013, 2014, 2015; Gilmartin et al., 2006), extending the discussion of underrepresented groups in the sciences – particularly, ethnic minority groups living in areas of extreme disadvantage.

This study showed that the four significant influences on science aspirations common to both East Los Angles samples were their own families' attitudes to science, their school science experiences, their own science self-concept, and their interaction with science outside of school. The findings also suggest that the relative strengths of these influences are a consequence of the context of this study. These results contribute to the current literature in science education examining historically underrepresented ethnic minorities attending school in low socioeconomic status neighbourhoods, providing empirical evidence of the importance of these four influences on the science aspirations of urban Latinos during secondary school years.

8.4.1.4 Demonstrating age differences in science aspirations and attitudes

This research showed that there was a dip in science aspirations and attitudes between the ages of 11 and 14 for the East Los Angeles students in this study. This result adds to the research examining the decline in science-related attitudes during secondary school years. It was suggested in this thesis that the differences in science aspirations and attitudes across ages were due to different developmental stages of thinking; the older 9th grade students were more

aware of the limits social context placed on their life chances, in comparison to the younger 6th grade students. The findings detailed the location of this study as a place where life opportunities were limited and simply surviving to high school was considered an accomplishment. Consequently, the 9th grade high school students' science aspirations were impacted – particularly the girls – by the layers of disadvantage associated with the neighbourhoods of East Los Angeles. This result contributes to the body of intersectional research in science education examining traditionally underrepresented ethnic minorities residing in low socioeconomic status areas, providing empirical evidence of the gendered decline in the science aspirations of urban Latinos between the ages of 11 and 14.

8.4.2 Theoretical development

A further contribution of this study to knowledge in science education is the fusing of ideas of social reproduction with theories of assimilation and social positioning in order to understand science aspirations. While both Bowles and Gintis's (1976) and Bourdieu and Passeron's (1990) perspectives on the reproduction of social inequalities in education provide a framework for understanding certain attitudinal influences on science aspirations (e.g., family attitudes towards science), the background characteristics utilized in the current study do not all fit clearly within a class-based categorization. For example, while concepts like socioeconomic status and even capital can be operationalized to account for variations in science aspirations, Bourdieu's concepts do not provide insight into differences in science aspirations among students with similar socioeconomic status and ethnicity, but different generation of immigration.

On the other hand, the work by Portes (1996) on segmented assimilation offers a way to understand differences in science aspirations and attitudes by immigration generation status. For instance, applying the concept of segmented assimilation to this study predicted first-generation science aspirations to be higher than those of the second-generation students theorized to have experienced downward-assimilation. However, applying Portes's concepts do not provide clarity into understanding why, for example, science self-concept strongly influences science aspirations in all immigration generations.

Thus, the results and findings of this study contribute three novel approaches to understanding science aspirations. First, this study theorized, operationalized, and explored student background characteristics not previously associated with Latino science aspirations. Second, this study successfully applied concepts from theories of reproduction in education, society, and culture in understanding why certain science-related attitudes were, or were not, significantly associated with Latino science aspirations. Third, this study applied the perspectives of Portes's (1996) theory of segmented assimilation in understanding the effects of immigration generation on Latino science aspirations.

8.4.2.1 Latino science aspirations and background characteristics

The literature suggested that several student characteristics could be quite influential on the science aspirations of students attending school in communities similar to East Los Angeles – background characteristics that had not been explored in previous studies of science aspirations and attitudes. Specifically, generation of immigration, home language use, and a measure of socioeconomic status unique to very disadvantaged areas were included in this study of science aspirations. The operationalization and application of these three background characteristics showed some significant group differences on the dependent variable, *Aspirations in science*. These background measures were used to predict science aspirations, although with limited success, as discussed previously in this chapter. However, the measures provided valuable contextual information with which to analyse similarities and differences between the 6th and 9th grade samples. Validation for the use of these measures in the study of urban Latino science aspirations was found in the teacher interviews. Consequently, this work contributes to the research of science aspirations within science education by generating, applying, and validating useful measures of home language use and generation of immigration, as well as a measure of socioeconomic status applied to very disadvantaged areas.

8.4.2.2 Latino science aspirations and social reproduction

The study of science aspirations is considered important because of wide agreement that science aspirations are related to science-related behaviours, which in turn are associated with science attainment. Given these relations, low science aspirations among the children of

historically underrepresented groups in science can be considered to be a form of reproduction of disadvantage. Bourdieu's perspectives applied to this study suggest that science aspirations are influenced by the interplay of the field of science education, the *habitus* of the students incorporating science attitudes, and forms of capital relevant to science. The results of this study highlight a pattern of alienation from future science participation that can be interpreted as arising from low "science capital" (Archer et al., 2015) and a set of interconnected science-related attitudes (i.e., dispositions or *habitus*); together these two influences shaped aspirations in the field of science to the extent that the great majority of these students, particularly the older ones, did not consider science as a future for themselves. The findings of the teacher interviews suggest that the students' *habitus* and science capital were heavily influenced by structured inequalities over which the students had little control: the context of the study, East Los Angeles. Thus, this study adds to the topic of student attitudes and aspirations towards science in science education by effectively applying Bourdieu's sociocultural perspectives in order to understand the science aspirations of Latino students in East Los Angeles.

Based on their correspondence principle, Bowles and Gintis (1976) argue that schools reinforce patterns of class, race and gender – reproducing the existing socioeconomic hierarchy of U.S. society. The empirical outcomes of this study align well with their view. The findings of the teacher interviews highlight the general detachment of the East Los Angeles community from science-related careers and science (e.g., "they don't see their parents – or their family or their neighbors – doing it"). The results of this study indicate that a future in science was not a popular aspiration among these students. Consequently, this research finds that the science aspirations of these students are consistent with the pattern of underparticipation in the sciences in East Los Angeles – reinforcing and reproducing one facet of East Los Angeles society. Thus, this research demonstrates that applying Bowles and Gintis's theoretical lens provides a useful sociocultural perspective of the role science aspirations play in science education and social reproduction.

8.4.2.3 Latino science aspirations and segmented assimilation

Portes's (1996) theory of segmented assimilation suggests that the first-generation students in East Los Angeles should have higher science aspirations than second- and third-generation

students. However, the survey analysis did not conclusively support the theorized outcomes; the results suggested that any effect generation status had on science aspirations was likely mediated through the attitudinal variables used in the analysis (e.g., family attitudes to science). The findings of the teacher interviews challenged the survey results: teachers argued that generation of immigration was directly linked to their students' science aspirations. Consequently, this work contributes to the body of intersectional research that focuses on the relations between multiple social positions and social inequality in science education by applying the theory of segmented assimilation to the understanding of urban Latino science aspirations and attitudes. This study also contributes to the to the body of intersectional research within the field of science education by operationalizing the theory of segmented assimilation (Portes, 1996) for use in research on science aspirations and attitudes.

8.5 Summary of the Discussion

This chapter discussed the results and findings of this study with respect to previous research, as well as this study's contributions to knowledge. The results and findings suggest that these students' science aspirations were deeply influenced by structural factors characteristic of the location of this study, factors which impact family attitudes to science, school science experiences, and science self-concepts. The results and findings of this study suggest that the influences on science aspirations act and interact in a multiplicity of ways, a complex network that acts to reduce these students' science aspirations across time. Thus, the main original contribution this thesis makes to knowledge is a rich, detailed, empirical understanding of the science aspirations and science-related attitudes of urban Latino secondary students in East Los Angeles. This research applied a unique theoretical perspective to the understanding of science aspirations and science-related attitudes in a very disadvantaged community. This theoretical approach could prove useful in future studies of science aspirations in communities similar to East Los Angeles, encouraging wider application of ideas from areas of social research outside of science education. The following and final chapter of this thesis considers the implications of this research for science education, the limitations of this study, and suggestions for future research based on this work.

CHAPTER 9 LIMITATIONS, IMPLICATIONS, AND FURTHER RESEARCH

9.1 Introduction

This chapter places the outcomes and contributions of this study into context by evaluating its limitations, explaining its implications, and suggesting directions for further research. This study set out to understand the science aspirations and science-related attitudes of urban Latino students based on empirical data from East Los Angeles; it was thought the study could provide knowledge useful in the development of practice and policy in science education. The results and findings suggest that most of these students were detached from science, strongly influenced by family, school experiences, and neighbourhood conditions. However, this study must be understood in light of its limitations, placing the implications of the study into perspective. The outcomes of this study point to several lines of research that are a natural progression of this work, expanding and building upon this study's empirical and theoretical findings. Note that while this research has provided deeper insight into the multiplicity of influences on the science aspirations of urban Latino youth, it cannot suggest a straightforward remedy to Latino underparticipation in the sciences. Nonetheless, the limitations, implications and directions for future research are presented here with the aspiration of assisting those who are interested in improving science education for all. This chapter begins by recognising the limitations of this research. Next, the implications of this study are detailed. This chapter concludes by making recommendations for further research work.

9.2 Limitations

The results and findings of this study are considered here in light of certain limitations of theory, design, and implementation.

9.2.1 Limitations of theory

This study was limited by three issues related to theory. The first limitation of theory stems from defining "science aspirations". The field of science is typically divided into two categories: the life sciences and the physical sciences. There is general agreement among science educators that each category engenders its own set of stereotypical attitudes and

aspirations among students, separate and distinct from one another (see the review by Tytler & Osborne, 2012). However, as it was thought unlikely that the 6th grade students (ages 11 to 12) in this study would be able to distinguish between the two science categories, the generic term science was used throughout. Consequently, for the 9th grade sample at least, the results of the current study should be confirmed or disconfirmed by future research examining Latino science aspirations specific to the life and physical sciences.

Second, this study was limited by the existing literature on urban Latino science aspirations. That is to say, to date there has been no research exploring and comparing U.S. urban Latino's science aspirations and science-related attitudes at 6th and 9th grade. Therefore, it is possible that important influences on urban Latino science aspirations were not included in this research. However, the general literature, together with the theoretical framework of this study, strongly suggested that the constructs and background measures included in the questionnaire would be sufficient for this exploratory study.

Nonetheless, future research into Latino science aspirations could usefully consider the findings of some previous studies into attitudes towards science (see the literature survey of Osborne et al., 2003) that were not applied to this research, findings that appear particularly relevant given the outcomes of this study. For example, the results of this study indicated a strong association between science self-concept and science aspirations. Consequently, in light of previous research showing that self-concept and achievement are substantially related (e.g., Strand, 2014a), a future study could consider using standardized measures of science-related achievement in place of an attitudinal construct of self-concept in science. Use of such standardized measures would reduce the study's reliance on self-reports of science-related attitudes, self-reports which can introduce unmeasured biases.

Third, this study was limited by the theoretical perspectives it employed, perspectives which did not fully predict nor explain the study's empirical results and findings. Portes's theory of segmented assimilation, for example, was operationalized and applied to this study through a measure of immigration generation status. The results of the survey analysis did not show a pattern of association between immigration generation and science aspirations. On the other

hand, the findings of the teacher interviews suggested that generation of immigration did influence science aspirations. However, as Portes's theory had not previously been applied to science aspirations there was always the possibility that the theory would be of limited use in understanding the outcomes of this study. As another example, Bourdieu theorized that children of lower socioeconomic status develop a culture that is incompatible with school culture. Thus, in a community such as East Los Angeles – where there is limited socioeconomic variation – one might expect very similar school-related attitudes and aspirations among students. The results of this study, however, indicated significant variation in school science-related attitudes within the samples. As a third example, Bowles and Gintis's theory is rather deterministic with respect to socioeconomic class and education: low socioeconomic class predicts low educational outcomes. Consequently, the theory does not account well, for instance, for the increase in working-class Latinos attending college in recent years (see Chapter 1 and 2). Nonetheless, the above theoretical limitations are not surprising: there is no grand unification theory of science aspirations (yet).

9.2.2 Limitations of design

9.2.2.1 Internal Validity

Another limitation of this study is its exploratory and correlational design. The correlational nature of the study precludes any claim that the science-related attitudinal constructs used as predictors cause science aspirations. For example, while this study found a consistent relation between science aspirations and school science experiences, it could not determine whether the relation was causal; this would require longitudinal data on changes in aspirations and attitudes between 6th and 9th grade for the same students over time. However, even longitudinal data does not unambiguously establish causal relations.

As a consequence of the exploratory nature of this research, for instance, this study did not examine (possible) bidirectional interactions between the attitudinal constructs and science aspirations; as well, it did not include all measures (e.g., achievement, teacher influences) that have been theorized to affect youth science aspirations. Nonetheless, this study provided valuable insight into the influences that shape the science aspirations of youth living in marginalized areas. Thus, given the exploratory design of this research, the results of this

study – together with its associated interpretations – require future research confirmation (or disconfirmation).

9.2.2.2 Measurement

The generalisability of these results is limited by the reliability of certain measures used in this study to predict science aspirations. To clarify, in order to be considered reliable a measurement should, among other things, be consistent across settings (Tabachnick & Fidell, 2013); that was not the case for several measures generated from the survey data. For example, while the socioeconomic variable was found to be reliable (as determined by Cronbach's alpha) when applied to the 6th-Extended sample, the measure was limited by the range of variation in the East Los Angeles sample. Consequently, as consistency of information is essential for making general statements, it is not possible to draw firm conclusions about the socioeconomic variable's association with the science aspirations of the East Los Angles samples.

As another example, the structure of several components extracted from the principal components analyses differed between samples[60]. Thus, a future study into Latino science aspirations could benefit from refinement of the survey instrument, based on the results and findings of this research. That is to say, the reliability of a number of components (e.g., experience of school science, self-concept in science) could be bolstered through revision of the items comprising them or, possibly, the removal of items. For instance, Kennedy, Quinn, and Taylor (2016) have argued that some science-related attitudinal constructs can reliably be reduced to single-item web-based visual analog scales. Applying such scales could also be useful in simplifying and streamlining the survey process in a future study, keeping the survey understandable for students and reducing instructional time lost to the survey.

This study was also limited by the researcher's choice of survey instrument, an instrument which included items adapted from a number of other preexisting scales. While use of the

[60] As well, the component structures that emerged in the East Los Angeles samples did not completely coincide with the U.K. findings of DeWitt et al. (2013, 2015).

survey enabled direct comparisons between studies, the instrument also included items not relevant to the current study (e.g., items measuring students' preferred school subject, absentee rate, outside of school activity preferences) which (unnecessarily) lengthened the time required to complete the survey. Further, although the survey items used in the analysis yielded interpretable component solutions with sufficient internal consistency (as measured by Cronbach's alpha), there were several cases of items cross loading onto components; the cross loading complicated interpretation of the components (see Chapter 4). Consequently, future research could usefully examine the theorisation and construct validity of the components in this study shown to have cross loaded items (e.g., experience of school science, self-concept in science).

9.2.2.3 Statistical analysis

This study was limited by the decision to employ an ordinary least squares regression (OLS) analysis of the survey data. While this method of analysis was sufficient for answering the questions posed by this research, a standard OLS model does not account for situations where individuals are nested in groups – as they were in this study. In this research students were nested at the levels of teachers and of schools, raising the possibility of statistical dependencies among the measurements in the sample. To clarify, nested students are thought to be more similar to each other than to students in other classrooms and schools (e.g., they have the same teachers and access to the same school resources); as a result, statistical dependency may occur[61]. Importantly, statistical dependency impacts the assumption of uncorrelated errors – a key assumption of OLS regression models (see Appendix 6). Violation of this assumption can lead to downwardly biased estimates of the standard errors associated with the regression coefficients, potentially leading to errors in the interpretation of the statistical significance of associations in the regression analysis (Hox, 2010).
Nested data can be analysed using multi-level modelling techniques. However, this study did not possess the resources needed to collect the type of data (20-25 groups per sample) necessary to carry out such an analysis (Hox, 2010). Thus, a future study of Latino science

[61] For example, a group-level characteristic (i.e., school attended) was used to predict individual science aspirations in this study.

aspirations in East Los Angeles would benefit from a sampling strategy (and resources) that enables data analysis utilizing multi-level modelling techniques.

9.2.2.4 External Validity

The generalisability of these results is subject to certain limitations. The sample selection of this study is only representative of the population of 6th and 9th grade public school students in East Los Angeles. As noted in this thesis, the population of Latinos residing in the U.S. is diverse and contains subgroups which have had different experiences historically. Clearly, the youths in this study are not representative of all Latino youth 10 to 14 years of age. Consequently, the generalization of the current study's results is limited and might not be generalizable to all Latinos. Nonetheless, these conclusions are relevant to the broader understanding of science aspirations among U.S. Latino youth, as well as similarly marginalized groups in the U.S. and other international contexts.

9.2.3 Limitations of implementation

This study was limited by a lack of access to student data theorized to be associated with science aspirations. For example, student math and science achievement scores on standardized tests would have provided valuable measures of science-related achievement for use in the prediction of science aspirations. However, due to school district policies, these achievement scores were not available to the researcher.

Another limitation emerged in the post-survey teacher interviews: not all teachers responded or agreed to participate in the interviews. Consequently, the findings of the interviews reflect only the views of the subgroup of teachers interviewed. Nonetheless, analysis of the teacher interviews provided useful perspectives on the science aspirations and science-related attitudes of students attending school in disadvantaged areas.

Notwithstanding the limitations discussed above, the current study was unique and effective in sampling a cross-section of urban Latino students. The data acquired by the study were assessed and met the assumptions necessary for the applied analysis techniques. The results and findings of this study's analysis simultaneously estimated and placed into context the

effects of science-related attitudes and background characteristics on these students' science aspirations.

9.3 Implications

This research has implication for science education policy and practice in Hispanic-serving institutions (HSI). This study identified two key factors shaping these Latino students' science aspirations: family science attitudes and school science experiences. However, the results and findings indicated that, for the majority of these students, families were not engaged with science in ways which might sustain and encourage science aspirations. Consequently, the evidence from this study suggests that, of the two, it is through school science that these student's science aspirations can be significantly impacted. The very positive school science experiences of students in one middle school in this study support the idea that schools in East Los Angeles can positively impact science aspirations. Note, though, that this research also showed that the science aspirations of these Latino students declined across middle school years and into high school. Thus, it is important for the science education community to be aware of the outsized role science teachers play in marginalized communities like East Los Angeles, a role not just in stimulating but in maintaining science aspirations through school science experiences. To be clear, this research does not suggest specific ways to improve school science; proponents of school science reform have promoted a variety of strategies (e.g., school science clubs, partnering with a STEM professional, teacher professional development), over many years, with the aim of influencing science-related attitudes and academic outcomes (e.g., National Research Council, 2007). Rather, based on the results and findings of this study, this thesis suggests that the science education community working with disadvantaged Latino communities re-think the goals of school science – accounting for its impact on science aspirations and, in turn, disrupting the cycle of Latino underparticipation in the sciences.

9.4 Further research

Based on the results and findings of this research, a natural progression of this work could usefully assess the time progression of science aspirations and attitudes of youth in Los Angeles. Such a study, on a larger scale than this research, is currently planned by this

researcher to be conducted within the Los Angeles Unified School District, a district with a student population of over 700,000. This future study would, with the cooperation of the district, be a longitudinal study tracking science aspiration from late primary school years to late secondary school (ages 9 to 17). This line of research would, among other things, gather the type of data required to better account for the nested nature of the students – which this study could not do. Further, a larger and more diverse sample would clarify the extent to which background characteristics such as gender, ethnicity/race, immigration generation, and socioeconomic status shape science aspirations and science-related attitudes.

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APPENDIX 1 SURVEYS

A1.1 ASPIRES survey questionnaire – 6th grade



This survey asks questions about you and your interests. What you have to say will help us make science lessons more interesting for other students.

There are no right or wrong answers for the questions. We want to know what you think. We will not share your answers with your teachers.

If you prefer not to answer a question, you do not have to!

Q1 About you

First Name:

Last Name:

Date of birth:

I am a ☐ boy

☐ girl

Which of the following best describes you?
*(mark **one or more** boxes)*

☐ White

☐ Black or African American

☐ Latino (Mexican, Mexican American, or Chicano)

☐ Latino (Please specify:)

☐ Asian (Please specify:)

☐ American Indian or Alaska Native

☐ Native Hawaiian or other Pacific Islander

Q2 In my spare time. . .

How often do you do the following things when you are NOT in school?
(*mark only **one** box in **each row***)

		At least once a week	*At least once a month*	*At least once a term*	*At least once a year*	*Never*
a.	Go to a museum	☐	☐	☐	☐	☐
b.	Do science activities (e.g., science kits, nature walks, do experiments)	☐	☐	☐	☐	☐
c.	Read a book or magazine about science	☐	☐	☐	☐	☐
d.	Visit web sites about science	☐	☐	☐	☐	☐
e.	Visit a science centre, science museum or zoo	☐	☐	☐	☐	☐
f.	Watch a TV programme about science or nature	☐	☐	☐	☐	☐
g.	Talk with someone at home about what I've been learning in school	☐	☐	☐	☐	☐

Q3 My family

*Mark **yes** or **no** for the following statements.*

		Yes	*No*	*I don't know*
a.	Did your mother go to college?	☐	☐	☐
b.	Did your father go to college?	☐	☐	☐
c.	Did your mother leave school before they were 16?	☐	☐	☐
d.	Did your father leave school before they were 16?	☐	☐	☐

*Mark **yes** or **no** for the following statements.*

		Yes	*No*
e.	Is there a computer at home that you use for schoolwork?	☐	☐
f.	Do you live in different homes with different people during the school year?	☐	☐

*Mark **one** box.*

		Own	*Rent*	*Other*
g.	Does your family own or rent your home, or have some other living arrangement?	☐	☐	☐

h. How many books are there in your home? (*mark **one** box*)

- None ☐
- Very few ☐
- One shelf filled with books ☐
- One bookcase filled with books ☐
- More than one bookcase filled with books ☐

i. How long has your family been in the US? *(mark **one or more boxes**)*

- I was born here ☐
- One or both of my parents were born here ☐
- One or more of my grandparents were born here ☐
- I was born in another country ☐

j. How often do people in your home talk to each other in a language other than English? *(mark **one box**)*

Never ☐

Once in a while ☐

About half of the time ☐

All or most of the time ☐

(If yes, please specify language:)

Which of the following items do you have in your home?

	*Mark **one box** for each row*	***We have***	***We do not have***
k.	Access to the Internet	☐	☐
l.	Cell phone	☐	☐
m.	Clothes dryer just for my family	☐	☐
n.	Electric dishwasher	☐	☐
o.	Electric garbage disposal	☐	☐
p.	More than six rooms (not including bathrooms)	☐	☐
q.	More than one bathroom	☐	☐
r.	A bedroom of my own	☐	☐
s.	Air conditioning in my whole home	☐	☐
t.	Three or more cars.	☐	☐

Q4 My parent/guardian's jobs

Please write a job description for your parents or guardians.

Mother (or guardian):

Father (or guardian):

Q5 More about my family…

How much do you agree with these statements about your family?

	*Mark **one box** for each row*	*Strongly agree*	*Agree*	*Neither agree nor disagree*	*Disagree*	*Strongly disagree*
a.	It is important to them that I get good grades in school.	☐	☐	☐	☐	☐
b.	It is important to them that I try my best in school.	☐	☐	☐	☐	☐
c.	They expect me to go to college.	☐	☐	☐	☐	☐
d.	They know how well I am doing in school.	☐	☐	☐	☐	☐
e.	They want me to get a good job when I grow up.	☐	☐	☐	☐	☐
f.	They want me to make a lot of money when I grow up.	☐	☐	☐	☐	☐
g.	They always attend parent conferences at school.	☐	☐	☐	☐	☐
h.	My family think science is interesting.	☐	☐	☐	☐	☐
i.	My family think it is important for me to learn science.	☐	☐	☐	☐	☐
j.	My family would be happy if I became a scientist when I grow up.	☐	☐	☐	☐	☐

Q6 My future…

When I get older, I would like to:

	*Mark **one box** for each row*	*Strongly agree*	*Agree*	*Neither agree nor disagree*	*Disagree*	*Strongly disagree*
a.	be a doctor or work in medicine.	☐	☐	☐	☐	☐
b.	work in science.	☐	☐	☐	☐	☐
c.	work in engineering.	☐	☐	☐	☐	☐
d.	be an inventor.	☐	☐	☐	☐	☐
e.	have a job like my mother's.	☐	☐	☐	☐	☐
f.	have a job like my father's.	☐	☐	☐	☐	☐

	*Mark **one** box*	*Very much*	*Some*	*Not at all*	*I don't know*	*Never thought about it*
g.	How much do you want to go to college?	☐	☐	☐	☐	☐

h. What would you like to be when you get older?

Q7 My classmates

How many of your classmates:

*Mark **one box** for each row*	*All*	*Nearly all*	*Some*	*A few*	*None*
a. Like science?	☐	☐	☐	☐	☐
b. Think science is cool?	☐	☐	☐	☐	☐
c. Get good grades in science?	☐	☐	☐	☐	☐
d. Care about their grades in school?	☐	☐	☐	☐	☐
e. Encourage you to do well in school?	☐	☐	☐	☐	☐
f. Are smart?	☐	☐	☐	☐	☐

Q8 Learning science in school….

How much do you agree with these statements?

*Mark **one box** for each row*	*Strongly agree*	*Agree*	*Neither agree nor disagree*	*Disagree*	*Strongly disagree*
a. My teacher expects me to do well in science.	☐	☐	☐	☐	☐
b. I get good grades in science.	☐	☐	☐	☐	☐
c. We learn interesting things in science class.	☐	☐	☐	☐	☐
d. I look forward to my science class.	☐	☐	☐	☐	☐
e. Science class is exciting.	☐	☐	☐	☐	☐
f. Studying science is useful for getting a good job in the future.	☐	☐	☐	☐	☐

Q9 Science lessons and me…

How much do you agree with these statements?

	*Mark **one box** for each row*	*Strongly agree*	*Agree*	*Neither agree nor disagree*	*Disagree*	*Strongly disagree*
a.	I find science difficult.	☐	☐	☐	☐	☐
b.	I am not good at science.	☐	☐	☐	☐	☐
c.	I learn things quickly in science class.	☐	☐	☐	☐	☐
d.	I understand everything in my science class.	☐	☐	☐	☐	☐
e.	Science is one of my best subjects.	☐	☐	☐	☐	☐
f.	If I study hard, I will do well in science.	☐	☐	☐	☐	☐
g.	I feel lost in science class.	☐	☐	☐	☐	☐
h.	I do well in science.	☐	☐	☐	☐	☐

Q10 More about me…

How much do you agree with these statements?

	*Mark **one box** for each row*	*Strongly agree*	*Agree*	*Neither agree nor disagree*	*Disagree*	*Strongly disagree*
a.	Most girls/boys like the same kinds of things that I do.	☐	☐	☐	☐	☐
b.	I would like to study more science in the future.	☐	☐	☐	☐	☐
c.	I would like to have a job that uses science.	☐	☐	☐	☐	☐
d.	I would like to become a scientist.	☐	☐	☐	☐	☐
e.	I think I could be a good scientist one day.	☐	☐	☐	☐	☐

g. Which of these school subjects do you like best, next best, and least? (*Mark **one** box for **each column***)

	Like best	*Next best*	*Least*
English	☐	☐	☐
Science	☐	☐	☐
Math	☐	☐	☐
History	☐	☐	☐
PE	☐	☐	☐

h. How many days were you absent from school in the last month? (*Mark **one box***)

0	*1 or 2*	*3 or 4*	*5 to 10*	*More than 10*
☐	☐	☐	☐	☐

Q11 Scientists and people who use science in their jobs…

How much do you agree with these statements? (*Mark **one** box for **each row**)*

	People who use science in their jobs:	*Strongly agree*	*Agree*	*Neither agree nor disagree*	*Disagree*	*Strongly disagree*
a.	can make a difference in the world	☐	☐	☐	☐	☐
b.	make a lot of money	☐	☐	☐	☐	☐
c.	have exciting jobs	☐	☐	☐	☐	☐
d.	are smart	☐	☐	☐	☐	☐
e.	are weird	☐	☐	☐	☐	☐
f.	are respected by people	☐	☐	☐	☐	☐
g.	spend most of their time working alone	☐	☐	☐	☐	☐
h.	don't have many other interests in life	☐	☐	☐	☐	☐

Q12 More about my future job

Here are some reasons for choosing a particular kind of work. How important is each reason to you?

	*(Mark **one** box for **each row**)*	*Very important*	*Fairly*	*Only a little*	*Not important*
a.	To earn a lot of money	☐	☐	☐	☐
b.	To make a difference in the world	☐	☐	☐	☐
c.	To have time for a family	☐	☐	☐	☐
d.	To work outdoors	☐	☐	☐	☐
e.	To work with others instead of by myself	☐	☐	☐	☐
f.	To have time for hobbies and other interests in my life	☐	☐	☐	☐
g.	To be my own boss	☐	☐	☐	☐
h.	To become famous	☐	☐	☐	☐
i.	To make, design or invent something	☐	☐	☐	☐
j.	To work with people rather than things	☐	☐	☐	☐
k.	To build or repair things using my hands	☐	☐	☐	☐

Q13 When you are not in school. . .

Other than watching TV, what do you like to do most?

Thank you for answering all these questions!

A1.2 ASPIRES survey questionnaire – 9th grade



This survey asks questions about you and your interests. What you have to say will help us make science lessons more interesting for other students.

There are no right or wrong answers for the questions. We want to know what you think. We will not share your answers with your teachers.

If you prefer not to answer a question, you do not have to!

Q1 About you

First Name:

Last Name:

Date of birth:

I am a ☐ Male

☐ Female

Which of the following best describes you?
*(mark **one or more** boxes)*

☐ White

☐ Black or African American

☐ Latino (Mexican, Mexican American, or Chicano)

☐ Latino (Please specify:)

☐ Asian (Please specify:)

☐ American Indian or Alaska Native

☐ Native Hawaiian or other Pacific Islander

Q2 In my spare time. . .

How often do you do the following things when you are NOT in school?
(*mark only **one** box in **each row***)

		At least once a week	*At least once a month*	*At least once a semester*	*At least once a year*	*Never*
a.	Go to a museum	☐	☐	☐	☐	☐
b.	Do science activities (e.g., science kits, nature walks, do experiments)	☐	☐	☐	☐	☐
c.	Read a book or magazine about science	☐	☐	☐	☐	☐
d.	Visit web sites about science	☐	☐	☐	☐	☐
e.	Visit a science centre, science museum or zoo	☐	☐	☐	☐	☐
f.	Watch a TV program about science or nature	☐	☐	☐	☐	☐
g.	Talk with someone at home about what I've been learning in school	☐	☐	☐	☐	☐

Q3 My family

*Mark **one** box for statement.*

		Yes	No	I don't know
a.	Did your mother go to college?	☐	☐	☐
b.	Did your father go to college?	☐	☐	☐
c.	Did your mother leave school before they were 16?	☐	☐	☐
d.	Did your father leave school before they were 16?	☐	☐	☐

*Mark **one** box for statement.*

		Yes	No
e.	Is there a computer at home that you use for schoolwork?	☐	☐
f.	Do you live in different homes with different people during the school year?	☐	☐

g. How many books are there in your home? (*mark **one** box*)

- ☐ None
- ☐ Very few
- ☐ One shelf filled with books
- ☐ One bookcase filled with books
- ☐ More than one bookcase filled with books

	*Mark **one** box.*	*Own or pay mortgage*	*Rent*	*Other*
h.	Does your family own or rent your home, or have some other living arrangement?	☐	☐	☐

i. How long has your family been in the US? *(mark **one or more boxes**)*

- ☐ I was born here
- ☐ One or both of my parents were born here
- ☐ One or more of my grandparents were born here
- ☐ I was born in another country

j. How often do people in your home talk to each other in a language other than English? *(mark **one box**)*

- Never ☐
- Once in a while ☐
- About half of the time ☐
- All or most of the time ☐

(If yes, please specify the language:)

Which of the following items do you have in your home?

*Mark **one box** for each row*		***We have***	***We do not have***
k.	Access to the Internet	☐	☐
l.	Cell phone	☐	☐
m.	Clothes dryer just for my family	☐	☐
n.	Electric dishwasher	☐	☐
o.	Electric garbage disposal	☐	☐
p.	More than six rooms (not including bathrooms)	☐	☐
q.	More than one bathroom	☐	☐
r.	My own bedroom	☐	☐
s.	Air conditioning in my whole home	☐	☐
t.	Three or more cars.	☐	☐

Q4 My parent/guardian's jobs

Please write a job description for your parents or guardians.

Mother (or guardian):

Father (or guardian):

Q5 More about my family…

How much do you agree with these statements about your family?

	*Mark **one box** for each row*	*Strongly agree*	*Agree*	*Neither agree nor disagree*	*Disagree*	*Strongly disagree*
a.	It is important to them that I get good grades in school.	☐	☐	☐	☐	☐
b.	It is important to them that I try my best in school.	☐	☐	☐	☐	☐
c.	They expect me to go to college.	☐	☐	☐	☐	☐
d.	They know how well I am doing in school.	☐	☐	☐	☐	☐
e.	They want me to get a good job when I grow up.	☐	☐	☐	☐	☐
f.	They want me to make a lot of money when I grow up.	☐	☐	☐	☐	☐
g.	They always attend parent conferences at school.	☐	☐	☐	☐	☐
h.	My family think science is interesting.	☐	☐	☐	☐	☐
i.	My family think it is important for me to learn science.	☐	☐	☐	☐	☐
k.	My family would be happy if I became a scientist when I grow up.	☐	☐	☐	☐	☐

Q6 My future…

When I get older, I would like to:

	*Mark **one box** for each row*	*Strongly agree*	*Agree*	*Neither agree nor disagree*	*Disagree*	*Strongly disagree*
a.	be a doctor or work in medicine.	☐	☐	☐	☐	☐
b.	work in science.	☐	☐	☐	☐	☐
c.	work in engineering.	☐	☐	☐	☐	☐
d.	be an inventor.	☐	☐	☐	☐	☐
e.	have a job like my mother's.	☐	☐	☐	☐	☐
f.	have a job like my father's.	☐	☐	☐	☐	☐

	*Mark **one** box*	*Very much*	*Some*	*Not at all*	*I don't know*	*Never thought about it*
g.	How much do you want to go to college?	☐	☐	☐	☐	☐

h. What would you like to be when you get older?

Q7 My classmates

How many of your classmates:

*Mark **one box** for each row*	*All*	*Nearly all*	*Some*	*A few*	*None*
a. Like science?	☐	☐	☐	☐	☐
b. Think science is cool?	☐	☐	☐	☐	☐
c. Get good grades in science?	☐	☐	☐	☐	☐
d. Care about their grades in school?	☐	☐	☐	☐	☐
h. Encourage you to do well in school?	☐	☐	☐	☐	☐
i. Are smart?	☐	☐	☐	☐	☐

Q8 Learning science in school….

How much do you agree with these statements?

*Mark **one box** for each row*	*Strongly agree*	*Agree*	*Neither agree nor disagree*	*Disagree*	*Strongly disagree*
a. My teacher expects me to do well in science.	☐	☐	☐	☐	☐
b. I get good grades in science.	☐	☐	☐	☐	☐
c. We learn interesting things in science.	☐	☐	☐	☐	☐
d. I look forward to my science class.	☐	☐	☐	☐	☐
e. Science class is exciting.	☐	☐	☐	☐	☐
f. Studying science is useful for getting a good job in the future.	☐	☐	☐	☐	☐
g. The main reason for studying science is to become a scientist	☐	☐	☐	☐	☐
h. My science teacher cares whether I understand science.	☐	☐	☐	☐	☐
i. Studying science can help me in the future.	☐	☐	☐	☐	☐
j. My science teacher is enthusiastic about science.	☐	☐	☐	☐	☐
k. I like my science teacher.	☐	☐	☐	☐	☐

l. Is there a STEM club at your school?	Yes ☐		No ☐		Not Sure ☐
m. If yes, do you go?	Yes ☐		No ☐		

Q9 Science lessons and me…

How much do you agree with these statements?

*Mark **one box** for each row*	*Strongly agree*	*Agree*	*Neither agree nor disagree*	*Disagree*	*Strongly disagree*
a. I find science difficult.	☐	☐	☐	☐	☐
b. I am not good at science.	☐	☐	☐	☐	☐
c. I learn things quickly in science class.	☐	☐	☐	☐	☐
d. I understand everything in my science class.	☐	☐	☐	☐	☐
e. Science is one of my best subjects.	☐	☐	☐	☐	☐
f. If I study hard, I will do well in science.	☐	☐	☐	☐	☐
g. I feel helpless in science class.	☐	☐	☐	☐	☐
h. I do well in science.	☐	☐	☐	☐	☐

Q10 Making choices

In the future you will get to pick some of your classes. How would you rank the following reasons for studying a subject in school?

*Mark **one** box for **each column***	*Most important*	*Next important*	*Least important*
a. How useful the subject is for my future job or career.	☐	☐	☐
b. How well I do in the subject.	☐	☐	☐
c. How much I enjoy the subject.	☐	☐	☐

Which of these science subjects do you plan to take in high school?
(*Mark **all boxes** that apply*)

d. Biology ☐

e. Chemistry ☐

f. Physics ☐

g. Environmental Science ☐

h. Other :

i. What do you plan to do after high school?
(*Mark **one box***)

Full-time college or university. ☐

Get a full-time job. ☐

Go to trade school. ☐

Go to school part-time. ☐

Join the military. ☐

Don't know. ☐

Other :

Q11 More about me…

How much do you agree with these statements?

*Mark **one box** for each row*	*Strongly agree*	*Agree*	*Neither agree nor disagree*	*Disagree*	*Strongly disagree*
a. Most girls/boys like the same kinds of things that I do.	☐	☐	☐	☐	☐
b. I would like to study more science in the future.	☐	☐	☐	☐	☐
c. I would like to have a job that uses science.	☐	☐	☐	☐	☐
d. I would like to become a scientist.	☐	☐	☐	☐	☐
e. I think I could be a good scientist one day.	☐	☐	☐	☐	☐

f. How many days were you absent from school in the last month?

*Mark **one box***	*0*	*1 or 2*	*3 or 4*	*5 to 10*	*More than 10*
	☐	☐	☐	☐	☐

Q12 School subjects

a. Which of these school subjects do you like best, next best, and least?
(*Mark **one** box for **each column***)

	Like best	*Next best*	*Least*
English	☐	☐	☐
Science	☐	☐	☐
Math	☐	☐	☐
History	☐	☐	☐
PE	☐	☐	☐

Q13 More about my future job

Here are some reasons for choosing a particular kind of work. How important is each reason to you?

*Mark **one** box for **each row***	*Very important*	*Fairly important*	*Only a little*	*Not important*
a. To earn a lot of money	☐	☐	☐	☐
b. To make a difference in the world	☐	☐	☐	☐
c. To help other people	☐	☐	☐	☐
d. To please my family	☐	☐	☐	☐

Q14 Scientists and people who use science in their jobs…

How much do you agree with these statements? (*Mark **one** box for **each row**)*

	People who use science in their jobs:	*Strongly agree*	*Agree*	*Neither agree nor disagree*	*Disagree*	*Strongly disagree*
a.	can make a difference in the world.	☐	☐	☐	☐	☐
b.	make a lot of money.	☐	☐	☐	☐	☐
c.	have exciting jobs.	☐	☐	☐	☐	☐
d.	are smart.	☐	☐	☐	☐	☐
e.	are weird.	☐	☐	☐	☐	☐
f.	are respected by people.	☐	☐	☐	☐	☐
g.	spend most of their time working alone.	☐	☐	☐	☐	☐
h.	don't have many other interests in life.	☐	☐	☐	☐	☐
i.	do valuable work.	☐	☐	☐	☐	☐
j.	have to be creative in their work.	☐	☐	☐	☐	☐
k.	are nerds.	☐	☐	☐	☐	☐

Thank you for answering these questions!

APPENDIX 2 INFORMATION SHEETS AND CONSENT FORMS

A2.1 School Information Form and School Consent Form

UNIVERSITY OF OXFORD
DEPARTMENT OF EDUCATION

15 Norham Gardens, Oxford OX2 6PY
Tel: +44(0)1865 274024 Fax: +44(0)1865 274027
general.enquiries@education.ox.ac.uk www.education.ox.ac.uk

Director Professor Ernesto Macaro

Aspirations in the Physical Sciences of Young People in Los Angeles

Dear Principal and Teachers,

My name is Leif Andersen-Monserratte, and I am a PhD (Science Education- Physics) student at the University of Oxford. I am also a credentialed Physics teacher and university lecturer who has taught science in LA for 20 years. As part of a PhD thesis, I am hoping to conduct a survey at your school. The aim of the research is to explore young people's science and career aspirations and resulting educational outcomes. The results of the study will be reported in my PhD thesis.

The proposed participants will be students enrolled in a physical science class at your school site and will involve a fifteen question multiple choice questionnaire. Individual students are asked to answer a multiple choice questionnaire, as I read the items aloud, regarding their aspirations and perceptions of science. The questionnaire takes approximately 20 minutes to complete. Upon completion of the questionnaire a hands-on physical science activity is planned to make up for lost instructional time.

By participating in the study, your school will contribute to our research project aiming at deepening knowledge and understanding of young people's science and career aspirations and educational outcomes. Research findings will attempt to shed light on the impact of the influences of family, school, career education, social identities and social inequalities on young people's science and career aspirations and, importantly, relate these to their actual subject choices and attainment in standardized examinations and their post-high school life choices.

If your school agrees to participate I hope to work out an appropriate schedule with your science teachers so there is minimal disruption to the normal classroom operation. All measures will be considered to ensure that the students are comfortable with the questionnaire and following activity. If your school agrees to participate an information sheet and consent form will be distributed to students' parents to obtain informed consent. I would like to stress that participation is voluntary and that any teacher or student is free to withdraw from the study at any time by simply advising the researcher. Any data already recorded will be discarded.

All data collected, as well consent forms, will be stored in a locked filing cabinet at the University of Oxford, and available only to me and my supervisors. Electronic data will be password encrypted. The study is not intended as an evaluation of a specific student. No reference to individuals will be made within the final report, and thus anonymity will be ensured. There is no perceived harm, risk, or possible injury anticipated from this proposed study. At the end of the study, I will send you a brief summary of the results. The study has been reviewed by, and received ethics clearance through the University of Oxford Central University Research Ethics Committee.

I hope you will be interested in participating in this research. If you have any questions or concerns at any time before, during or after the project please feel free to contact me at leif.andersen@education.ox.ac.uk (626-285-1831), or my supervisor judith.hillier@education.ox.ac.uk .

I would be grateful if you could complete the pro-forma attached. Please feel free to email me, use the enclosed self-addressed envelope, or I am available to pick it up in person. I look forward to your response.

Kind regards,

Leif Andersen-Monserratte
PhD Candidate in Science Education (Physics)
Oxford University Department of Education
15 Norham Gardens
Oxford
OX2 6PY

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Director Professor Ernesto Macaro

Aspirations in the Physical Sciences of Young People in Los Angeles
Researcher: Leif Andersen-Monserratte

School Agreement to participate:

I hereby confirm that (please tick box):

- ☐ my school wishes to participate in this study.
- ☐ my school does not wish to participate in this study.

School Name:_____

Principal Name:_____

Principal Signature:_____ Date:_____

Please return this form by using the enclosed self-addressed envelope, or I am available to pick it up in person.

A2.2 Teacher Consent Form and Parent Information Sheet

UNIVERSITY OF OXFORD
DEPARTMENT OF EDUCATION

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general.enquiries@education.ox.ac.uk www.education.ox.ac.uk

Director Professor Ernesto Macaro

Aspirations in the Physical Sciences of Young People in Los Angeles

Researcher: Leif Andersen-Monserratte

Teachers Declaration of Consent:

I hereby confirm that (please tick boxes):

- ☐ I have read the participant information sheet and have had the opportunity to ask questions about the study and receive satisfactory answers to questions.
- ☐ I understand that the participation is voluntary and that my students and I are free to withdraw from the study at any time by simply advising the researcher, and any data already recorded will be discarded.
- ☐ I understand that this project has been reviewed by, and received ethics clearance through, the University of Oxford Central University Research Ethics Committee.
- ☐ I understand that all personal data will be treated in total confidence, kept securely in a password-controlled server; and what will happen to the data at the end of the project.
- ☐ I understand that I will have the opportunity to review and comment on any analysis before publication. I understand how to raise a concern and make a complaint, and agree to participate in this study.

Your Name:_____

Your Signature: _____ Date:_____

Researcher: Leif Andersen-Monserratte

Signature:_____ Date:_____

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DEPARTMENT OF EDUCATION

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Director Professor Ernesto Macaro

Aspirations in the Physical Sciences of Young People in Los Angeles
Information for Participants

Invitation

In partnership with the University of Oxford, your child's school has kindly agreed to participate in a research study on STEM education. Before you decide to participate, it is important to understand why the research is being conducted and what your child's participation entails. Please take time to read the following information carefully. Please ask if there are any aspects of the project that are unclear or if you would like more information. Take time to decide whether or not you would like to take part in this research.

What is the purpose of the study?

This study is an exploration of young people's science and career aspirations and resulting educational outcomes. It is an attempt to understand the influences of family, school, career education, social identities and social inequalities on young people's science and career aspirations and, importantly, relate these to their actual subject choices and attainment in standardized examinations and their post-high school life choices.

Why has my child been chosen?

For this study, we are seeking schools that are representative of the demographics of Los Angeles. Your child's school has been identified as such a school. The hope is that by obtaining a wide range of schools the fullest possible picture of young people's science and career aspirations can be explored.

Do I have to take part? What are the risks and benefits of taking part?

It is your and your child's decision to take part in this study. You can decide to stop participating at any time by simply advising the researcher. Your child does not need to answer questions that they do not wish to. Every effort will be made to preserve confidentiality. There are no known risks to taking part. The benefit to participating is helping to create a picture of young people's science and career aspirations and educational outcomes in Los Angeles. Your participation, as part of this study, will benefit those trying to understand and plan STEM educational policies and those interested in understanding inequities between STEM aspirations and attainment among young people in Los Angeles. If you do not wish your child to participate in this study, simply complete the attached opt-out form and return it to your child's science teacher. If you do not return the opt-out form it will be assumed that you agree to your child's participation in the study. If you choose not to participate there will be no negative consequences for your child.

What will happen to the results of this research?

The results of this research will form the basis of an Oxford doctoral dissertation. Some results may be published in academic journals concerned with science education. If you wish to obtain a copy of the published results, please inform the researcher. The study will take place over the next two to three years after which time the published results will be publicly available. All data collected will be stored in a locked filing cabinet at the University of Oxford, and available only to me and my supervisors. Electronic data will be password encrypted.

Who is funding and organizing the research?

The research is funded and organized as an independent doctoral research project in conjunction with the Department of Education, Oxford University.

Contact for Further Information or Follow-up:

Should you have any further questions about this research, please feel free to contact:

Leif Andersen-Monserrate,
Department of Education,
15 Norham Gardens,
Oxford, UK OX2 6PY.

leif.andersen@education.ox.ac.uk.

A2.3 Parent Opt-out Form and School Information Sheet for discussion group

UNIVERSITY OF OXFORD
DEPARTMENT OF EDUCATION

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Director Professor Ernesto Macaro

Aspirations in the Physical Sciences of Young People in Los Angeles

Researcher: Leif Andersen-Monserratte

Parent/Guardian 'opt-out' form:

If you DO NOT wish your child to participate in the Aspirations in the Physical Sciences of Young People in Los Angeles study, please complete this form:

Following the review of the information sheet on this study, I am choosing to 'opt-out' my child from participating in the Aspirations in the Physical Sciences of Young People in Los Angeles study. I understand that he/she will be allowed to remain in the classroom while the survey is conducted, and that he/she will receive an alternative lesson if deemed appropriate by the school.

Name of Student:_____

Science Teacher:_____

Parent/Guardian Name:_____

Parent/Guardian Signature: _____ Date:_____

Please return this form to your child's science teacher.

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Director Professor Ernesto Macaro

Aspirations in the Physical Sciences of Young People in Los Angeles

Dear Principal and Teachers,

My name is Leif Andersen-Monserratte, and I am a PhD (Science Education- Physics) student at the University of Oxford. I am also a credentialed Physics teacher and university lecturer who has taught science in LA for 20 years. As part of a PhD thesis, I am hoping to conduct a discussion group at your school. The discussion group's purpose is to seek out potential problems of context and comprehension with a survey questionnaire about young people's science and career aspirations and resulting educational outcomes. The results of the study will be reported in my PhD thesis.

The proposed participants would be eight students enrolled in a sixth grade physical science class at your school site. The discussion will involve two thirty minute guided discussions about a fifteen question multiple choice questionnaire regarding their aspirations and perceptions of science. Individual students are asked to participate in the group discussion and give their thoughts and interpretations of items on the questionnaire. The discussion groups are proposed to occur during the students' lunch period in order to avoid lost instructional time.

By participating in the study, your school will contribute to our research project aiming at deepening knowledge and understanding of young people's science and career aspirations and educational outcomes. Research findings will attempt to shed light on the impact of the influences of family, school, career education, social identities and social inequalities on young people's science and career aspirations and, importantly, relate these to their actual subject choices and attainment in standardized examinations and their post-high school life choices.

If your school agrees to participate I hope to work out an appropriate schedule with your science teachers so there is minimal disruption to the students' daily routine. If your school agrees to participate an information sheet and consent form will be distributed to students' parents to obtain informed consent. The discussion group will involve audio recording of student responses and the consent form will contain an explicit statement to this effect. Recordings will not be made available to those outside the research group. I would like to stress that participation is voluntary and that any teacher or student is free to withdraw from the study at any time by simply advising the researcher. Any data already recorded will be discarded. All measures will be considered to ensure that the students are comfortable with the discussion group.

All data collected, as well consent forms, will be stored in a locked filing cabinet at the University of Oxford, and available only to me and my supervisors. Electronic data will be password encrypted. The study is not intended as an evaluation of a specific student. No reference to individuals will be made within the final report, and thus anonymity will be ensured. There is no perceived harm, risk, or possible injury anticipated from this proposed study. At the end of the study, I will send you a brief summary of the results. The study has been reviewed by, and received ethics clearance through the University of Oxford Central University Research Ethics Committee.

I hope you will be interested in participating in this research. If you have any questions or concerns at any time before, during or after the project please feel free to contact me at leif.andersen@education.ox.ac.uk (626-285-1831), or my supervisor judith.hillier@education.ox.ac.uk . I would be grateful if you could complete the pro-forma attached. Please feel free to email me, use the enclosed self-addressed envelope, or I am available to pick it up in person. I look forward to your response.

Kind regards,

Leif Andersen-Monserratte
PhD Candidate in Science Education (Physics)
Oxford University Department of Education
15 Norham Gardens, Oxford OX2 6PY

A2.4 School Consent Form and Teacher Consent Form for discussion group

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Director Professor Ernesto Macaro

Aspirations in the Physical Sciences of Young People in Los Angeles
Researcher: Leif Andersen-Monserratte

School Agreement to participate:

I hereby confirm that (please tick box):

- ☐ my school wishes to participate in this study.
- ☐ my school does not wish to participate in this study.

School Name:_____

Principal Name:_____

Principal Signature:_____ Date:_____

Please return this form by using the enclosed self-addressed envelope, or I am available to pick it up in person.

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Director Professor Ernesto Macaro

Aspirations in the Physical Sciences of Young People in Los Angeles

Researcher: Leif Andersen-Monserratte

Teachers Declaration of Consent:

I hereby confirm that (please tick boxes):

- ☐ I have read the participant information sheet and have had the opportunity to ask questions about the study and receive satisfactory answers to questions.
- ☐ I understand that the participation is voluntary and that my students and I are free to withdraw from the study at any time by simply advising the researcher, and any data already recorded will be discarded.
- ☐ I understand that this project has been reviewed by, and received ethics clearance through, the University of Oxford Central University Research Ethics Committee.
- ☐ I understand that all personal data will be treated in total confidence, kept securely in a password-controlled server; and what will happen to the data at the end of the project.
- ☐ I understand that I will have the opportunity to review and comment on any analysis before publication. I understand how to raise a concern and make a complaint, and agree to participate in this study.
- ☐ I understand that there will be an audio recording of the discussion group and I agree to be audio recorded.

Your Name:_____

Your Signature: _____ Date:_____

Researcher: Leif Andersen-Monserratte

Signature:_____ Date:_____

A2.5 Parent Information Sheet and Consent Form for discussion group

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Director Professor Ernesto Macaro

Aspirations in the Physical Sciences of Young People in Los Angele
Information for Participants

Invitation
In partnership with the University of Oxford, your child's school has kindly agreed to participate in a research study on STEM education. Before you decide to participate,it is important to understand why the research is being conducted and what your child's participationentails. Please take time to read the following information carefully. Please ask if there are any aspects of the project that are unclear or if you would like more information. Take time to decide whether or not you would like to take part in this research.

What is the purpose of the study?
This study is an exploration of young people's science and career aspirations and resulting educational outcomes. It is an attempt to understand the influences of family, school, career education, social identities and social inequalities on young people's science and career aspirations and, importantly, relate these to their actual subject choices and attainment in standardized examinations and their post-high school life choices.

Why has my child been chosen?
For this study, we are seeking schools that are representative of the demographics of Los Angeles. Your child's school has been identified as such a school. The hope is that by obtaining a wide range of schools the fullest possible picture of young people's science and career aspirations can be~~e[illegible]~~d

Do I have to take part? What are the risks and benefits of takingpart?
It is your and your child's decision to take part in this study. You can decide to stop participating at any time by simply advising the researcher. Your child does not need to answer questions that they do not wish to. Every effort will be made to preserve confidentiality. There are no known risks to taking part. The benefit to participating is helping to create a picture of young people's science and career aspirations and educational outcomes in Los Angeles. Your participation, as part of this study, will benefit those trying to understand and plan STEM educational policies and those interested in understanding inequities between STEM aspirations and attainment among young people in Los Angeles. Your child will be in a small discussion group with 3 peers and the researcher in a classroom at lunchbreak and so they will not miss any class time. The discussion group will involve audio recording of students' responses. Recordings will not be made available to those outside the research group. If you do not object to your child participating in this study, please complete the attached opt-in permission form and return it to your child's science teacher. If you choose not to participate there will be no negative consequences for your child. The verbal assent of your child to be audio-recorded will also be obtained at the start of the discussion group.

What will happen to the results of this research?
The results of this research will form the basis of an Oxford doctoral dissertation. Some results may be published in academic journals concerned with science education. If you wish to obtain a copy of the published results, please inform the researcher. The study will take place over the next two to three years after which time the published results will be publicly available. All data collected will be stored in a locked filing cabinet at the University of Oxford, and available only to me and my supervisors. Electronic data will be password encrypted.

Who is funding and organizing the research?
The research is funded and organized as an independent doctoral research project in conjunction with the Department of Education, Oxford University.

Contact for Further Information or Follow-up:
Should you have any further questions about this research, please feel free tocontact:

Leif Andersen-Monserrate,
Department of Education,
15 Norham Gardens,
Oxford, UK
OX2 6PY.

leif.andersen@education.ox.ac.uk.
Your inquiries are most welcome.

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Director Professor Ernesto Macaro

Aspirations in the Physical Sciences of Young People in Los Angeles

Researcher: Leif Andersen-Monserratte

Parent/Guardian consent form:

I hereby confirm that (please tick boxes):

- ☐ I have read the participant information sheet and have had the opportunity to ask questions about the study and receive satisfactory answers to questions.
- ☐ I understand that the participation is voluntary and my child and I are free to withdraw from the study at any time by simply advising the researcher, and any data already recorded will be discarded.
- ☐ I understand that this project has been reviewed by, and received ethics clearance through, the University of Oxford Central University Research Ethics Committee.
- ☐ I understand that all personal data will be treated in total confidence, kept securely in a password-controlled server; and what will happen to the data at the end of the project.
- ☐ I understand how to raise a concern and make a complaint, and give permission for my child to participate in this study.
- ☐ I understand that there will be an audio recording of the discussion group and I agree that my child can be audio recorded.

Name of Student:_____

Parent/Guardian Name:_____

Parent/Guardian Signature: _____ Date:_____

Please return to your child's science teacher.

APPENDIX 3 CUREC 1A – MAIN STUDY

CUREC 1A Checklist

CENTRAL UNIVERSITY RESEARCH ETHICS COMMITTEE (CUREC)
CUREC 1A Checklist for the Social Sciences and Humanities

The University of Oxford places a high value on the knowledge, expertise, and integrity of its members and their ability to conduct research to high standards of scholarship and ethics. The research ethics clearance procedures have been established to ensure that the University is meeting its obligations as a responsible institution. They start from the presumption that all members of the University will take their responsibilities and obligations seriously and will ensure that their research on human subjects is conducted according to the established principles and good practice in their fields and in accordance, where appropriate, with legal requirements. Since the requirements of research ethics review will vary from field to field and from project to project, the University accepts that different guidelines and procedures will be appropriate. Please check the CUREC website to ensure that you have the correct checklist for your project.

ONLY TYPE-WRITTEN CHECKLISTS WILL BE ACCEPTED. PLEASE DO NOT SEND HANDWRITTEN CHECKLISTS

ONLY EMAILED APPLICATIONS WILL BE ACCEPTED. PLEASE DO NOT SEND APPLICATIONS BY POST

WHAT THIS CHECKLIST IS DESIGNED FOR

This CUREC 1A checklist is designed largely for research that falls within the Divisions of Social Sciences and Humanities where ethical issues are relatively few and straightforward. Interviews, field work and oral history are also included in the CUREC process.

The full CUREC 2 application is only required where certain project characteristics (e.g. type of participants, or procedures) result in a more complex set of ethical issues. It is expected that only in a limited number of cases will it be necessary for researchers to complete a CUREC 2 application. The checklist below will direct you to a CUREC 2 application if needed.

WHAT THIS CHECKLIST WILL NOT ASSESS

This checklist does not cover research governance, satisfactory methodology, or compliance with the requirements of publishers when administering their tests or questionnaires. As principal researcher, it is your responsibility to ensure that requirements in these areas are met.

CUREC does not review studies classed as ***audit*** (see glossary and Decision Flowchart for CUREC on our website).

The use of an ***asterisked word underlined*** in this checklist indicates a phrase defined in CUREC's glossary. The glossary and further information on the University's research ethics procedures are available from the CUREC website: www.admin.ox.ac.uk/curec

Office use only:

IDREC Ref. No.

Date of confirmation that checklist accepted on behalf of IDREC: (dd/mm/year)

Please complete the sections that follow and follow prompts to stop completion and/or submit other documents.

Please indicate your answer to all the Yes / No questions with a type-written 'X'.

Example:		
1. *By taking part in the research, will participants be at serious risk of criminal prosecution (e.g. by providing information on drug abuse or child abuse?*	Yes	No X

SECTION A: Filter for CUREC2 application

This section determines whether your study raises more complex issues which require the completion of a full application for ethical review, known as the CUREC/2 application.

(Please mark 'X' in the Yes/No column as appropriate to indicate your response.)

1. Are research participants classed as ***people whose ability to give free and informed consent is in question*** ? (This may include those under 18 (though see FAQ C12), prisoners or vulnerable adults.) (**Note**: sometimes participants aged 16-17 are regarded as 'competent youths' and may be able to consent for research themselves. Please consult the FAQ C12 on the CUREC website. However, if any of your participants are aged 16 or under, please answer 'Yes' here and also answer question 4 below.)	Yes X	No
2. By taking part in the research, will participants be at serious risk of criminal prosecution (e.g. by providing information on drug abuse or child abuse)?	Yes	No X
3. Does the research involve the ***deception*** of participants?	Yes	No X

If you have answered 'No' to all of the questions above please go to **Section B**. If you have answered 'Yes' to any question above continue to question 4 below.

4. Is your project covered by one of our approved research protocol(s)? (See CUREC website)	Yes X	No
If yes, please give protocol number(s): IDREC P25 Children in research		

If you answered 'Yes' to ANY of questions 1-3, and answered 'No' to question 4, **please stop completing this checklist and do not submit it for ethical review**.
Instead, please complete the CUREC/2 application form, available to download from the CUREC website. Then submit the CUREC/2 for ethical review.
If you answered 'Yes' to ANY of questions 1-3, and answered 'Yes' to question 4, please go on to **Section B**.

SECTION B: Contact details and project description (NB: must be typed not handwritten)

Contact details:	
1. ***Principal researcher*** /supervisor (title and name) (if student research):	Doctor Judith Hillier Professor Steve Strand
2. Name of student (if student research):	Leif Andersen
3. Degree programme, e.g. DPhil, BA, MPhil, BSc, MSc (if student research):	DPhil
4. Department or Institute name:	Education
5. Address for correspondence (if different from 4 above):	
6. University e-mail and telephone contact:	leif.andersen@pmb.ox.ac.uk
7. Name and status of others taking part in the project, e.g. third year undergraduate; postdoctoral research assistant:	N/A
Project description:	
8. Title of research project:	Aspirations and the Underrepresentation of Latinos in the Physical Sciences in Los Angeles, California, USA
9. List of location(s) where project will be conducted:	Middle and High Schools within the Los Angeles Unified School District
10. If your research involves overseas travel or fieldwork, by the time the research starts, will you have completed and returned a travel risk assessment form? (This may be necessary to ensure that the activity is covered by the University's travel insurance – see www.admin.ox.ac.uk/finance/insurance/travel)	Yes X No N/A

/Section B (continued)

SECTION B: Contact details and project description (NB: must be typed not handwritten) (continued)	
11. Anticipated duration of project:	15 months
12.&13. Anticipated start and end dates:	From: 04/01/2016 To: 06/08/2017

14. Title and brief lay description of *research* (about 150 words), plus description (about 200 words) of the nature of participants.

When describing the research, please include your methodology, how you are applying professional guidelines, and the use to which results/data will be put. Please also declare any conflicts of interest here.

When describing participants, please include criteria for inclusion/exclusion, method of recruitment, and processes (as appropriate) for consent to participate. To support your description please attach documentation such as:

- recruitment and advertisement material e.g. a poster or invitation letter
- information for participants to read before they agree to take part e.g. participant information sheet(s)
- a document to record informed consent e.g. written consent form(s) or oral consent script in case of an oral consent process
- a guide to interview questions (this may be a list of questions to be asked, or a preliminary scope of questions) or sample of other instruments such as a sample questionnaire
- debriefing document after participants have taken part (if relevant)

Detailed guidance is found on the CUREC website

Title and brief lay description of research (150 words):

Title:

Aspirations and the Underrepresentation of Latinos in the Physical Sciences in Los Angeles, California, USA.

Overview:

This study is a systematic investigation of the aspirations of U.S. Latino youth towards education and careers in the physical sciences. Now the largest racial and ethnic minority group in the United States, Latinos make up a bigger share of the US population than African Americans. Los Angeles, California and in particular the neighbourhoods of East Los Angeles (East LA) represents the most populous and some of the oldest settlements of Mexican Americans and other Latin American immigrants in the United States. Nevertheless, and despite the size of the population, Latino participation in STEM degrees is disproportionately low, and while intervention programs have been designed to increase interest in physical sciences, the number of Latinos taking STEM degrees continues to lag behind Whites and Asian Americans. This research aims to fill a gap in knowledge in the scholarly literature addressing a critical aspect in the pipeline from middle school to high school and beyond in aspirations to study physical science.

Key Questions:

1. What are the aspirations of 6th Grade Latino students to study the physical sciences?
2. What are the aspirations of 9th Grade Latino students to study the physical sciences?
3. Are there differences in science aspirations between the above two (cross-sectional) samples?
4. Which factors predict the strength of aspirations to study science in the East Los Angeles sample? In particular, what is the role of student attitude to school and science self-concept, parental attitudes to science, peer attitudes to science, images of scientists and engagement in science related activities outside of school?
5. What are the associations between science aspirations and age, gender, socio-economic status and other student characteristics?

Methodology:

Using the ASPIRES questionnaire (DeWitt, J., Osborne, J., Archer, L., Dillon, J., Willis, B. & Wong, B. (2011). High aspirations but low progression: The science aspirations-career paradox amongst minority ethnic students. *International Journal of Science and Mathematics Education*, 9 (2), 243-271), a correlational questionnaire designed to explore science aspirations and engagement among 10-14 year olds, I propose to collect survey data from a sample of middle school and high school students in East LA (approximately 2,000 students). Data will be gathered systematically from a sample of 6th grade science and 9th grade science classrooms and teachers attending twelve public middle and high schools in the East LA area of the Los Angeles Unified School District (LAUSD). Focus groups consisting of approximately 10 students per school are planned in order to provide participant feedback as the study progresses. For purposes of comparison, an additional sample of university student at California State University, Los Angeles will participate by answering a modified ASPIRES questionnaire.

A pilot study to explore the suitability of using the ASPIRES questionnaire (see appendices J,K, &L) in the Los Angeles, California, USA context was conducted in December, 2015, for which CUREC approval was obtained (14th October 2015). The pilot study provided evidence that the instrument could be successfully completed by American students in East LA. Modifications to the questionnaire involved only the replacement of UK-specific terms in the questionnaire with their US equivalents.

Uses of results:

It is hoped that utilizing the methodology described in this section will help identify the influences daily environments, lived experiences and social inequalities have on young people in East Los Angeles' aspirations to study the physical sciences. As well, this study will attempt to relate these influences to potential differences in aspirations amongst age groups within East Los Angeles. Finally, this research will attempt to identify relationships between aspirations and student characteristics in the East Los Angles context.

Description of participants and obtaining informed consent (200 words):

To be consistent with the aim of the study, the proposed sample is targeted at the East Los Angeles (East LA) area of the Los Angeles Unified School District (LAUSD). LAUSD is the largest school district in the state of California, serving approximately 700,000 students. Participants will consist of middle (11-12 year olds) and high school students (14-15 year olds) enrolled in science courses in the six inclusive public middle schools and six high schools located in East LA. It is estimated that approximately nine in ten of the participants will be Latino, and the remaining proportion a combination of Asian American, White, and African American students, reflecting the demographic composition of the neighbourhood schools.

Approval for the study has been obtained from local district East of LAUSD. Invitation letters and consent forms will be sent to principals and teachers of the selected schools (see appendices A,B,E, &F). Teachers who do not opt-out will be asked to fill in a teacher questionnaire (see appendix I). Next information sheets with consent forms will be sent to parents of participating students with the option to 'opt-out' for the questionnaire, and 'opt-in' for the focus groups (see appendices C,D,G, & H). All students, with the exception of students whose parents have chosen to opt-out, will participate in the questionnaire. Only students whose parents have consented will participate in the focus groups. It will be emphasized to students that participation is voluntary and they can withdraw at any time without consequence to themselves. College age students (18+), will be provided with an information sheet and consent form emphasizing that participation is voluntary (see appendices M & N).

Relevant documents are attached as appendices.

15. What are the ethical issues connected with your research and what steps have you taken to address them? Please do not answer 'none'.
The committee wants to see evidence that you have identified potential ethical issues with respect to your research and have taken steps to address them. These issues could relate to your own safety as a researcher, participant burdens/risks, and data protection/confidentiality. For more guidance on ethical issues, please see http://www.admin.ox.ac.uk/curec/resources/.

Ethical Issues and Professional Guidelines:

Protocol 25 (Protocol for studies using non-invasive methods with children) applies to this study because the age of the children (11-14 year olds) calls into question their ability to give free and informed consent. Coverage of required points listed in the protocol are detailed in the Information Sheet for Parents attached to this document as an appendix.

There is no perceived harm, risk, or possible injury anticipated from this proposed study. Personal or sensitive data will be captured, transferred, and stored securely per Protocol 25. This is detailed in Section B.19 of this document.

Conflicts of interest:

There are no perceived conflicts of interest.

/Section B (continued)

SECTION B: Contact details and project description (NB: must be typed not handwritten) (continued)

16. Will you obtain informed consent according to CUREC guidelines and good practice in your discipline before participation?	Yes X	No
If you have marked 'No', please give a brief explanation and justification for this decision here:		
17. Will your research involve discussing sensitive issues? This could be inforamtion relating to race or ethnic origin, political opinions, religious beliefs, physical/mental health, trade union membership, sexual life or criminal activities.	Yes	No X
If you have marked 'Yes', please make sure that you have included some supporting information (as directed in question 13 of this section) showing the range of questions covering these issues.		
18. Will you ensure that "personal data" collected directly from participants or via a "third party" is held and processed in accordance with the provisions of the Data Protection Act?	Yes X	No
19. How will you ensure that any personal or sensitive data are captured, transferred and stored securely? In particular if data are to be captured electronically, please consult with your local IT department and, with respect to University IT security policies, please comment on how you will capture such data in the first instance, how you will transfer them over networks or via portable media and how and where data will be stored. For more information please see the University's web pages on research data management: http://researchdata.ox.ac.uk/university-of-oxford-policy-on-the-management-of-research-data-and-records/		

Data will be captured, transferred, and stored securely per Protocol 25. No reference to individuals will be made within the final report, and thus anonymity will be upheld. All consent forms and individual paper-records will be kept in a locked filing cabinet. Anonymized data keys will be stored separately from data sets. The anonymized data in SPSS format will be securely stored by the researcher on password encrypted storage media. The researcher's supervisor will have copies of this data, also password encrypted. Electronic data will be stored indefinitely, while hard copy data will be destroyed five years after the project. There is no perceived harm, risk, or possible injury anticipated from this proposed study.

SECTION C: Methods and procedures to be used

Method used:	Please mark 'X'
1. Analysis of existing records	
2. Snowball sampling (recruiting through contacts of existing participants)	
3. Use of casual or local workers e.g. interpreters	
4. Participant observation	
5. Covert observation	
6. Observation of specific organisational practices	
7. Participant completes questionnaire in hard copy	X
8. Participant completes online questionnaire or other online task	
9. Using social media	
10. Participant performs paper and pencil task	
11. Participant performs verbal or aural task (e.g. for linguistic study)	
12. Focus group	X
13. Interview	
14. Audio recording of participant	X
15. Video recording of participant	
16. Photography of participant	
17. Others (please specify):	

SECTION D: Professional guidelines and training		
In this section, please mark 'X' against at least one of the following professional guidelines. You should use the principles listed in your chosen guideline(s) in conducting your own research. **Note**: this is not an exhaustive list.		**Please mark 'X'**
Research specialism/ methodology	**Association and guidance document (active links below)**	
Anthropology	Association of Social Anthropologists of the UK and Commonwealth	
Criminology	British Society of Criminology: Code of Ethics for Researchers in the Field of Criminology	
Education	British Educational Research Association Ethical Guidelines for Educational Research	X
Geography	Association of American Geographers Statement on Professional Ethics	
Geography	Royal Geographical Society: Research Ethics and Code of Practice	
History	Oral History Society of the UK Ethical Guidelines	
Law (Socio-Legal)	Socio-Legal Studies Association: Statement of Principles of Ethical Research	
Management	Academy of Management's Professional Code of Ethics	
Political Science	American Political Science Association (APSA) Guide to Professional Ethics in Political Science	
Politics	Political Studies Association. Guidelines for Good Professional Conduct	
Psychology	British Psychological Society Code of Ethics and Conduct British Psychological Society: Conducting Research on the Internet: (Guidelines for internet-mediated research)	
Social Research	Social Research Association: Ethical Guidelines	
Sociology	The British Sociological Association: Statement of Ethical Practice	
Visual Research	ESRC National Centre for Research Methods Review Paper: Visual Ethics: Ethical Issues in Visual Research	
Psychology	British Psychological Society Code of Ethics and Conduct British Psychological Society: Conducting Research on the Internet: (Guidelines for internet-mediated research)	
Social Research	Social Research Association: Ethical Guidelines	
Sociology	The British Sociological Association: Statement of Ethical Practice	
Visual Research	ESRC National Centre for Research Methods Review Paper: Visual Ethics: Ethical Issues in Visual Research	
Other professional guidelines. Please specify the other guidelines used here:		

1. Please indicate what training in research ethics the researchers involved with this study have received, e.g. the title of the course and date completed (online training available at http://www.admin.ox.ac.uk/curec/training/

If no formal training has been received, please indicate any discussions of research methodology between researchers and supervisors here.

Research ethics training was completed as part of the first year PRS training (2014- 2015).

A pilot study was conducted in December 2015 to identify potential issues with the ASPIRES questionnaire being used in a different cultural context.

SECTION E: Signatures	
Please ensure this checklist is signed by:	
For staff research:	For student research:
1. *Principal researcher*	1. *Principal researcher* (project supervisor)
2. Head of Department (or nominee)	2. Head of Department (or nominee)
	3. Student researcher

1. Principal researcher signature/supervisor signature (if student research)

I understand my responsibilities as *principal researcher* as outlined in the CUREC glossary and guidance on the CUREC website.

I declare that the answers above accurately describe the research as presently designed and that a new checklist will be submitted should the research design change in a way which would alter any of the above responses so as to require completion of CUREC/2 (involving full scrutiny by an IDREC). I will inform the relevant IDREC if I cease to be the principal researcher on this project and supply the name and contact details of my successor if appropriate.

Signed by principal researcher/supervisor: .....

Print name (block capitals): ..... **Date:** .....

2. Departmental endorsement signature

I have read the research project application named above. On the basis of the information available to me, I:

(i) consider the principal researcher to be aware of her/his ethical responsibilities in regard to this research;

(ii) consider that any ethical issues raised have been satisfactorily resolved or are covered by relevant professional guidelines and/or CUREC approved protocols, and that it is appropriate for the research to proceed (noting the principal researcher's obligation to report should the design of the research change in a way which would alter any of the above responses so as to require completion of a CUREC/2 full application);

(iii) am satisfied that: the proposed project design and scientific methodology is sound; the project has been/will be subject to appropriate *peer review*; and is likely to contribute to existing knowledge and/or to the education and training of the researcher(s) and that it is in the *public interest*.

Signed by Head of Department or nominee *(example nominees for student research include the Director of Graduate Studies/Director of Undergraduate Studies)*:

Signature: .....

Print name (block capitals): ..... **Date:** .....

3. Student signature (if student research)

I understand the questions and answers that have been entered above describing the research, and I will ensure that my practice in this research complies with these answers, subject to any modifications made by the principal researcher properly authorised by the CUREC system.

Signed by student: .....

Print name (block capitals): LEIF ANDERSEN **Date**: March 1, 2016

SECTION F: Final check before submitting your application	
	Please mark 'X'
Have you completed Sections A-E?	X
Have you included copies of any documentation produced with your application? **If the appropriate supporting documentation is not included with your application, you will then be asked to provide this separately. This may well delay the ethical review process, and thus the start of your research.**	X
Have you signed as principal researcher and gathered signatures of the student (for student research) and department nominees as appropriate?	
Have you declared conflicts of interest (if any) in Section B, question 14?	X
Are all pages (including supporting document attachments) numbered?	X
Have you defined all technical terms and abbreviations used?	X

HOW TO SUBMIT THE COMPLETED CHECKLIST

- If your department has a Departmental Research Ethics Committee (DREC), submit this checklist and supporting information to the appropriate departmental officer. To see a list of DRECs, go to www.admin.ox.ac.uk/curec/about/sshidrec/drecs/
- If your department does not have a DREC, submit the checklist and supporting information to the SSH IDREC (email ethics@socsci.ox.ac.uk).
- **NB** applications must be sent by email. Please do not send applications by post.

Note on how to send signatures needed in Section E

- If you have obtained handwritten (wet-ink) signatures, please scan them plus the rest of the checklist pages to create a single PDF document and email through.
- Alternatively, we accept 'electronic signatures' sent as email confirmations from a University of Oxford email address. Separate emails should come from each of the relevant signatories as outlined in Section E, indicating acceptance of the relevant responsibilities.

IDRECs and/or CUREC will review a sample of completed checklists and may ask for further details of any project.

APPENDIX 4 MATERIAL FROM CHAPTER 4

A4.1 Data assessment and assumption testing – 6th grade PCA

A4.1.1 Data screening – 6th grade

Data input was verified by randomly selecting 5% (27) of the 6th grade questionnaires and comparing the original responses to the corresponding responses in the database. A total of 12 items out of a possible 1,566 (58 items x 27questionnaires) were found to have been incorrectly inputted; they were subsequently corrected. The data was next screened for univariate outliers. Nine out-of-range values, caused by input error, were identified using SPSS 22 *Frequencies* command and replaced with the correct values obtained from the corresponding questionnaire. With a sample size of 539 students and 58 items, the subject to item ratio of 9.29 meets the minimum criteria of 5:1 suggested by Gorsuch for data used in a principal components analysis (Gorsuch,1983, p. 332). A full assessment of the suitability of the 6th grade data for a principal components analysis is detailed below.

A4.1.2 Assumption testing – 6th grade

A principal components analysis (PCA) of the 6th grade data was carried out in order to identify and explore dimensions among the items of the questionnaire, for which PCA is considered psychometrically sound and appropriate (Field, 2013). To clarify, PCA is an analysis method that is applied to a set of variables in order to determine which variables combine together to form conceptual constructs, or "components". Variables that group as a component are well correlated; that component is generally independent from other components formed from the remaining variables (Tabachnik & Fidell, 2013). In order to conduct a valid principal components analysis, the data used must be assessed, ensuring that specific assumptions are met. These assumptions include (1) sampling adequacy (sufficient sample size) and (2) factorability, where factorability is the assumption that there are at least some correlations among the variables so that coherent factors can be identified (Tabachnik & Fidell, 2013).

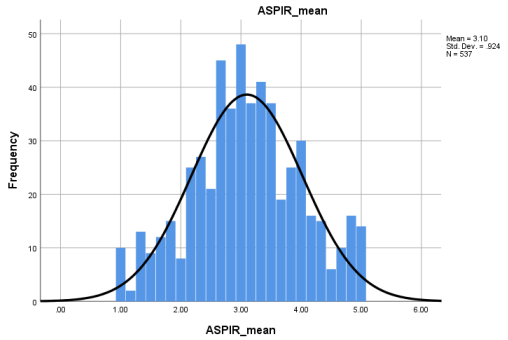
The sampling adequacy of the 6th grade data was tested in SPSS 22 using the Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy. The KMO is the ratio of the squared correlation

between variables to the squared partial correlation between variables; it is a metric commonly used in determining sampling adequacy (Field, 2013). A value close to one indicates "that patterns of correlations are relatively compact and should yield distinct and reliable factors" (Field, 2013, p. 788). The KMO measure of sampling adequacy was determined to be .909, above the recommended value of .6 (Field, 2013, p. 788). KMO for individual items (taken from the diagonal of the anti-image correlation matrix) were no lower than .629; the accepted limit is .5 (Field, 2013).

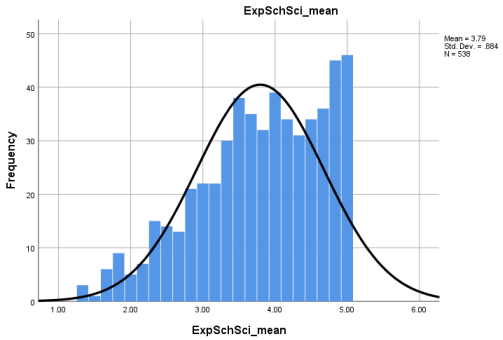
Next, the factorability of the 58 survey items was investigated. A number of widely accepted indicators of the factorability of a correlation matrix were applied to the 6th grade data. First, the correlations between items[62] theorized to belong to a specific construct were examined within the correlation matrix. Without exception all correlations were above .3 with at least one other item, suggesting reasonable factorability of the data (Tabachnik & Fidell, 2013). Bartlett's Test of Sphericity, χ^2 (1035) = 6580.65, $p < .001$, also indicated that correlations between the items were sufficiently large for a PCA. Bartlett's test examines whether dependent variables are correlated by testing whether the variance - covariance matrix is proportional to the identity matrix (Field, 2013, p. 781). Last, communalities were all above .3, which provided further confirmation that each item shared some common variance with other items. Taken together, these criteria provide a sound basis for the application of a principal components analysis to 58 6th grade survey items.

[62] The correlation matrix is available in Excel format upon request.

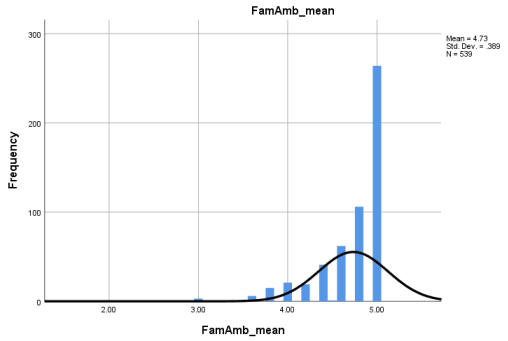
A4.2 Histograms of 6th grade component scores



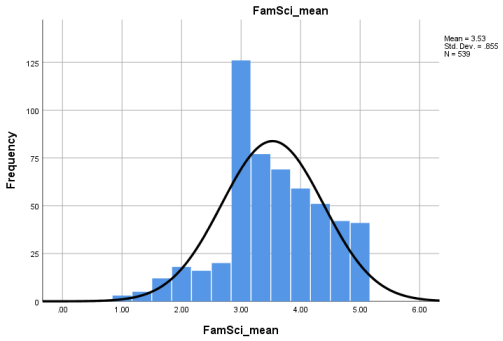
Aspirations in science



Experience of school science



Family involvement



Family attitudes to science

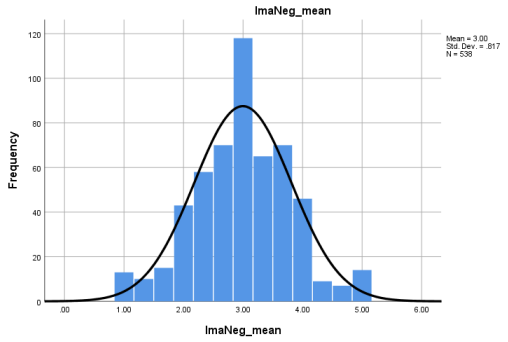


Image of scientist-negative

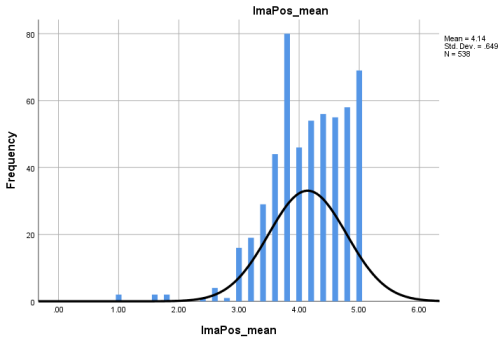
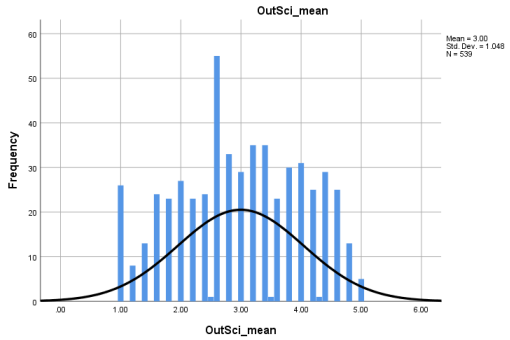
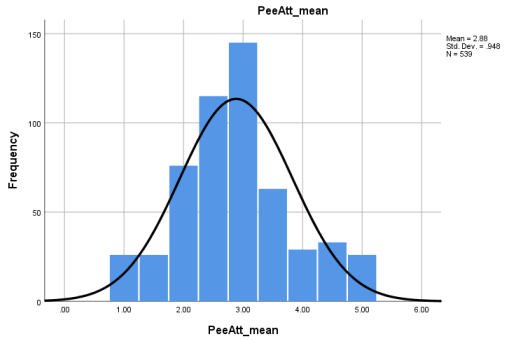


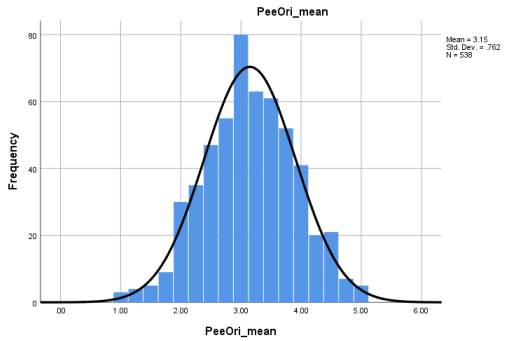
Image of scientist-positive



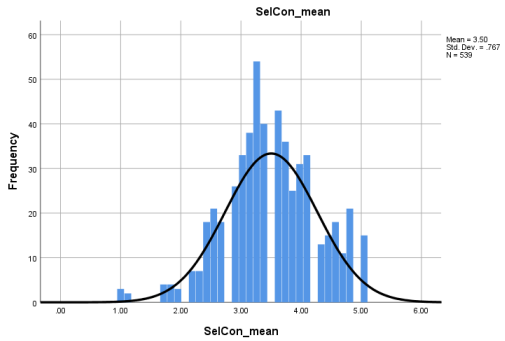
Outside of school science



Peer attitudes to science



Peer orientation to school



Self-concept in science

A4.3 Data assessment and assumption testing – 9th grade PCA

A4.3.1 Data screening – 9th grade

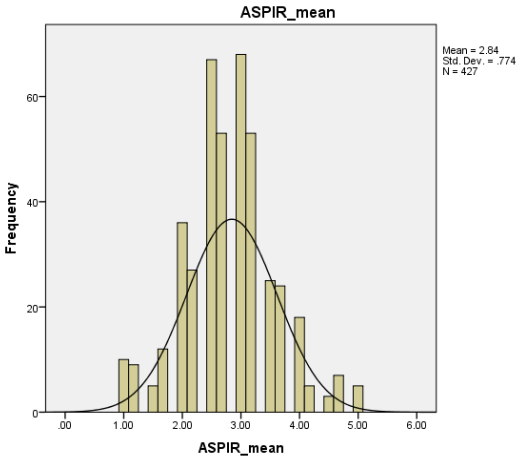
Data input was verified by randomly selecting 5% (21) of the 9th grade questionnaires and checking the original responses to the corresponding responses in the database. A total of 3 items of a possible 1,092 (52 items x 21questionnaires) were found to have been incorrectly input; the items were corrected. The data was then screened for univariate outliers: seven out-of-range values, caused by input error, were identified and replaced with the correct values obtained from the corresponding questionnaire. With a final sample size of 426 students (using listwise deletion) and 56 items used in the principal components analysis, the subject to item ratio of 7.6:1 meets the minimum criteria of 5:1 suggested by Gorsuch (1983, p. 332). The suitability of the data for a principal components analysis was examined next.

A4.3.2 Assumption testing – 9th grade

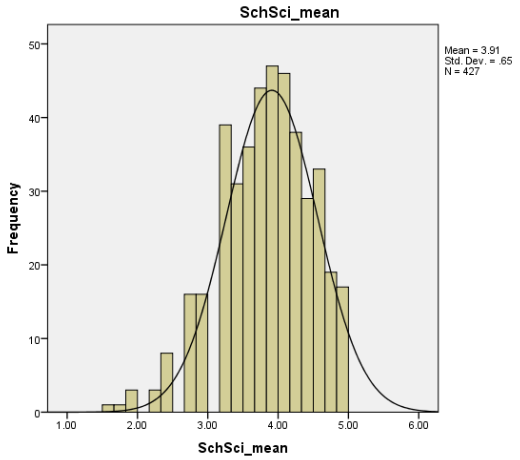
The sampling adequacy and factorability of the 9th grade data was assessed for use in a principal components analysis. The KMO measure of sampling adequacy was determined to be .870, above the recommended value of .6 (Field, 2013). KMO for individual items (taken from the diagonal of the anti-image correlation matrix) were all greater than .547, where the acceptable limit is .5 (Field, 2013).

The factorability of 56 survey items was next examined. All correlations were above .3 with at least one other item, suggesting reasonable factorability of the data (Tabachnik & Fidell, 2013). Bartlett's Test of Sphericity, χ^2 (1830) = 12970.20, $p < .001$, showed that correlations between the items were sufficiently large for a PCA. Communalities were all above .3, providing further confirmation that each item shared some common variance with other items. These criteria provide support for the application of a principal components analysis to 56 9th grade survey items.

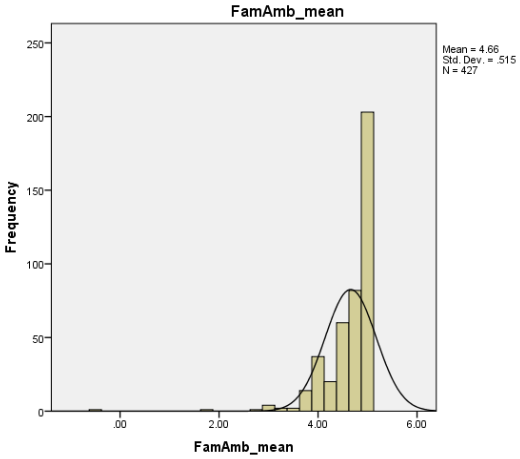
A4.4 Histograms of 9th grade component scores



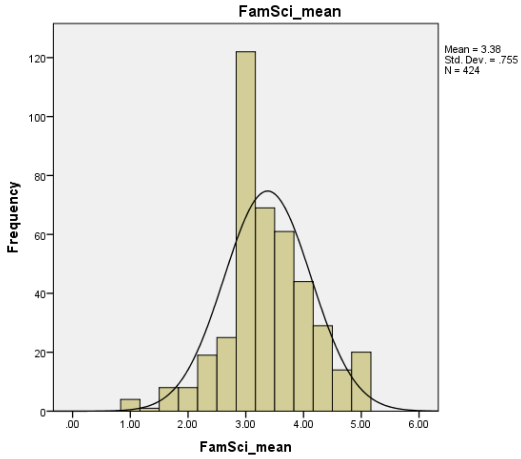
Aspirations in science



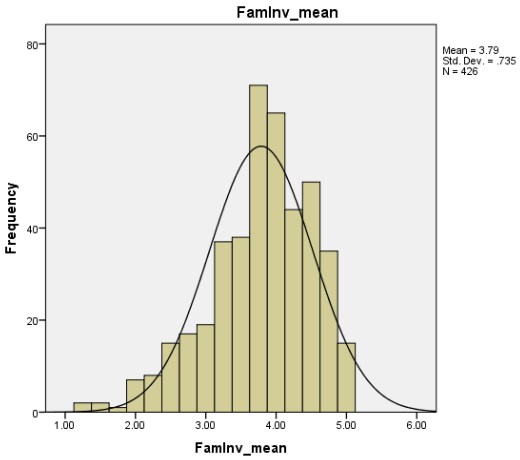
Experience of school science



Family ambitions



Family attitudes to science



Family involvement

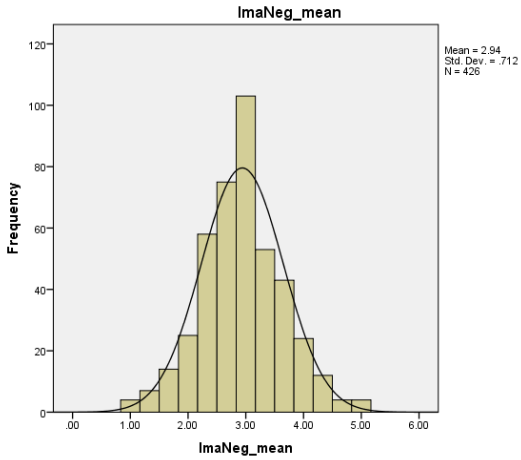


Image of scientist-negative

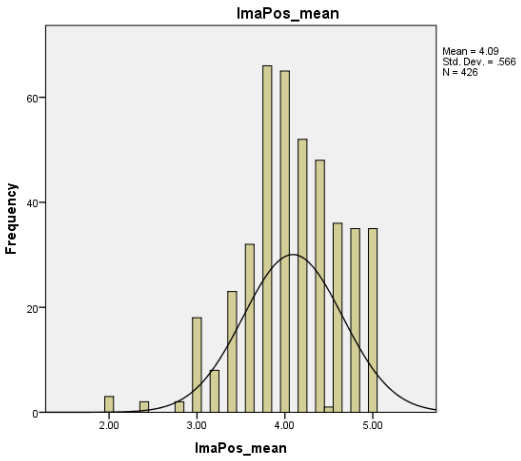
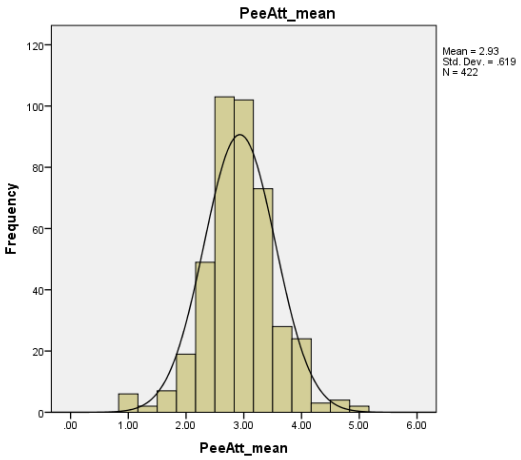
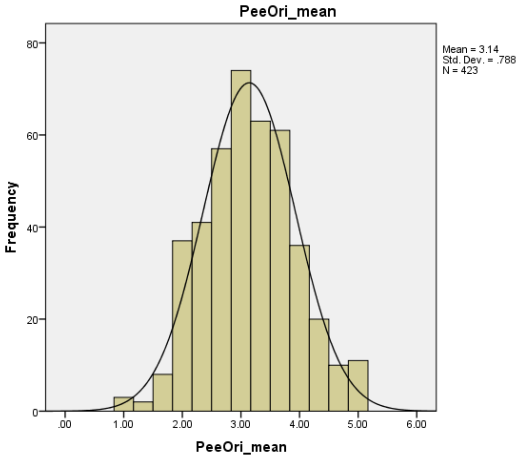


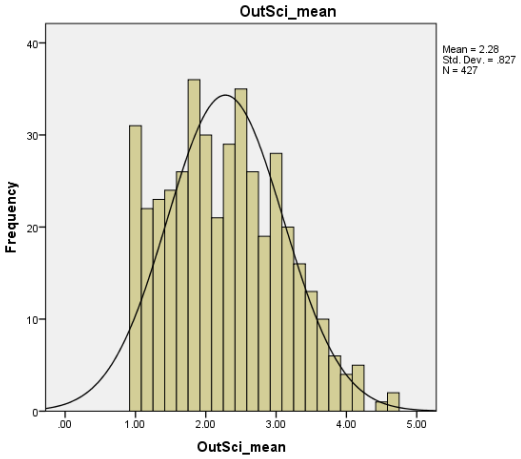
Image of scientist-positive



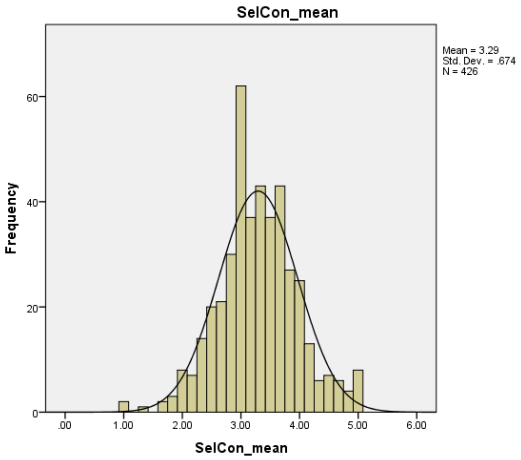
Peer attitudes to science



Peer orientation to school



Outside of school science



Self-concept in science

A4.5 Mapping of items onto 9th grade components – Extended from Section 4.3.4.2

Family ambitions – 9th grade

Family ambitions refer to a family's desires for their children's future. The items that make up this component are: How much do you agree with these statements about your family…

- q5a It is important to them that I get good grades in school.
- q5b It is important to them that I try my best in school.
- q5c They expect me to go to college.
- q5e They want me to get a good job when I grow up.
- q5f They want me to make a lot of money when I grow up.

Figure A4.1 displays item scores by percentage on this component, with the percentage of the combined categories of 'agree' and 'strongly agree' shown in the 'agree' band. The large majority 9th grade students agreed or strongly agreed (mainly over 90%) with these five

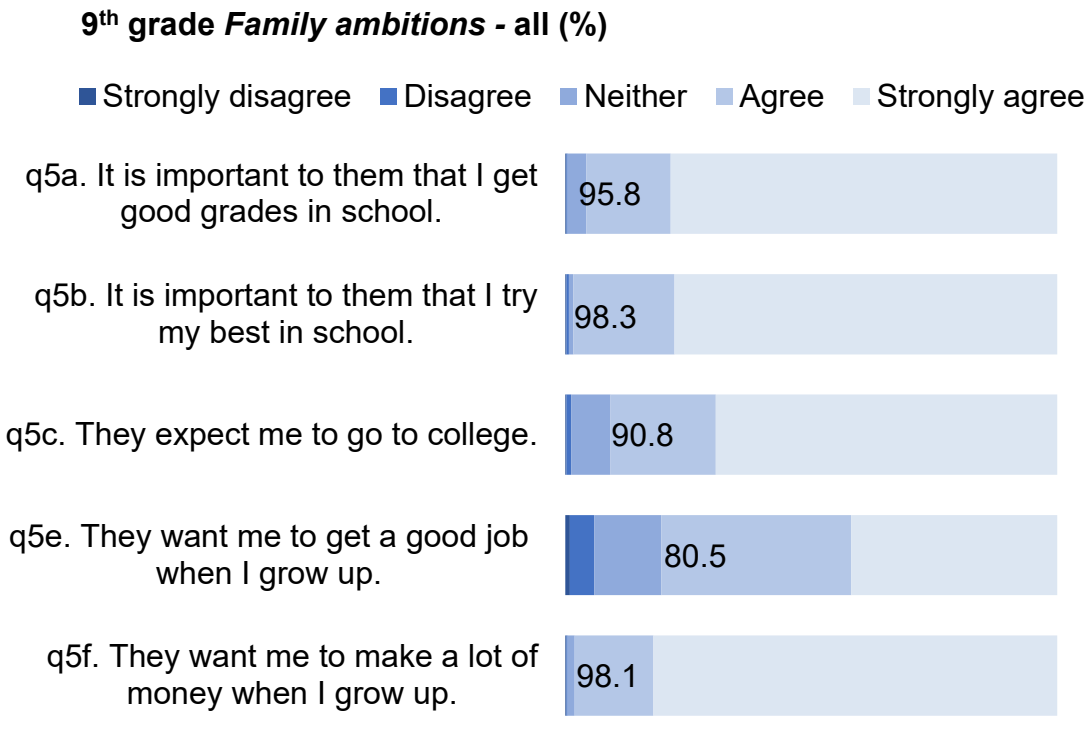


Figure A4.1. Item responses for the 9th grade component *Family ambitions*.

statements. Nearly all the students (98.3%) agreed or strongly agreed that their parents wanted them to do their best in school (q5b).

Note that this component was dichotomized for use in the multiple regression analysis, given its highly negatively skewed and leptokurtic distribution (see Table 4.6). Scores of 4.00 and above, corresponding to average responses of 'agree' or 'strongly agree', were assigned a value of one. Scores less than 4.00, corresponding to average responses of 'neither agree nor disagree', 'disagree', or 'strongly disagree', were assigned a value of zero.

Family involvement – 9th grade

Family support in this context is students' perceptions of their family's involvement in their school life. The items making up this component are: How much do you agree with these statements about your family…

- q5d They know how well I am doing in school.
- q5g They always attend parent conferences at school.

While this construct is comprised of two items clearly related to family support, it must be noted that two other items loaded primarily on this component as well. Item 'q8b I get good grades in science' had a loading of .697 on this component, although it was theorized to load on the question stem for *Experience of school science* (.259). Item, 'q9h I do well in science', was expected to load onto *Self-concept in science* (.427), but had a loading of .620 on *Family involvement*. Interpretation of a component consisting of these four items together was unnecessarily convoluted and, consequently, options for the component were considered.

One option was to utilize the cross loadings of the two theorized *Family involvement* items, with the idea of moving the items into other components. Specifically, item 'q5d They know how well I am doing in school' had a secondary loading of .312 on *Family ambitions*, while 'q5g They always attend parent conferences at school' loaded secondarily on *Family attitudes in science* (.446). This option was discarded – it unnecessarily lowered the reliability of *Family ambitions* and *Family attitudes to science*. In the final analysis, this component was structured only with the two items from the *Family involvement* question stem. Although the

two-item structure resulted in a relatively low internal consistency measure (Cronbach's alpha α = .568), the *Family involvement* component was retained given the theorized importance of family influences in this study.

Figure A4.2 shows item scores by percentage, with the percentage of the combined categories of "agree" and "strongly agree" displayed. The majority of students agreed with the two items that made up this component. For example, about four in five students (80.5%) agreed or strongly agreed that their family knew how well they were doing in school (q5d).

Peer orientation to school – 9th grade

The three items asking about peer orientation to school were: How many of your classmates…

- q7d Care about their grades in school?
- q7e Encourage you to do well in school?
- q7f Are smart?

Figure A4.3 presents item scores by percentage, with the percentage for the combined categories 'all' and 'nearly all' displayed. The student response patterns on these three items varied. For instance, on item q7e approximately one third of the 9th grade students thought all or nearly all of their classmates were encouraging in school (34.4%), while another third thought few to none (30.2%). In terms of academics, only one out of five students (19.5%) thought that all or nearly all of their peers cared about their school grades; nearly half thought that few to none cared (item q7d).

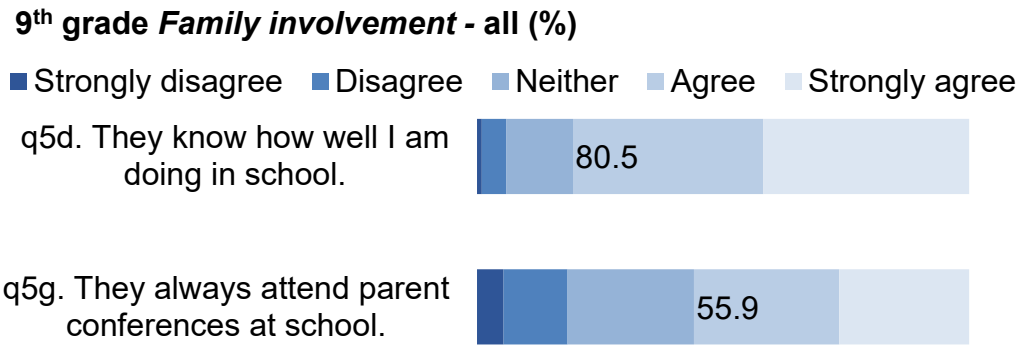


Figure A4.2. Item responses for the 9th grade component *Family involvement*.

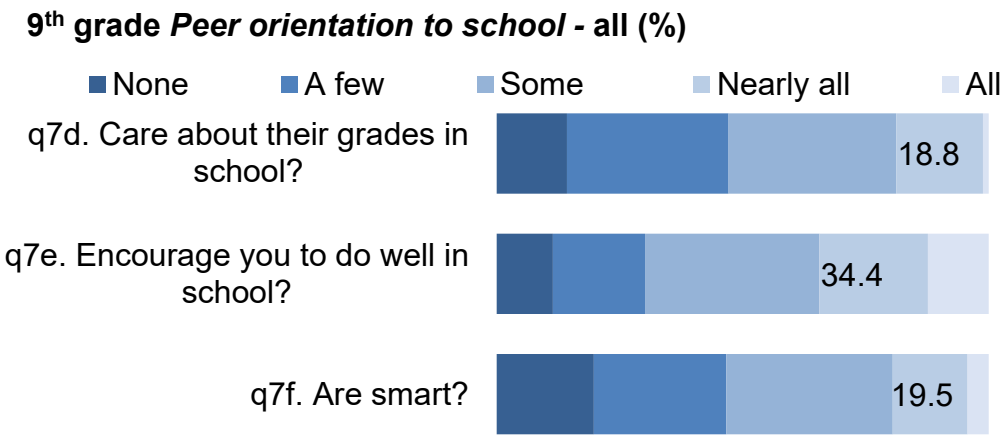


Figure A4.3. Item responses for the 9th grade component *Peer orientation to science.*

Image of scientists-positive – 9th grade

The set of five items that grouped as the positive image of scientists were: Scientists and people who use science in their jobs...

- q14a can make a difference in the world.
- q14b make a lot of money.
- q14c have exciting jobs.
- q14d are smart.
- q14f are respected by people.

Figure A4.4 displays item scores by percentage, with the percentage of the combined categories of 'agree' and 'strongly agree' shown in the 'agree' band. Responses to all five items on this component reveal very positive attitudes towards scientists. Specifically, more than four-fifths of the 9th grade students agreed or strongly agreed to the three items 'q14a can make a difference in the world (85.0%)', 'q14b make a lot of money' (81.54%), and 'q14d are smart' (87.0%). However, fewer students (68.4%) thought that scientists had exciting jobs (q14c). More insight into these students' thoughts on scientists is obtained by examining the response patterns for items asking about their negative images of scientists.

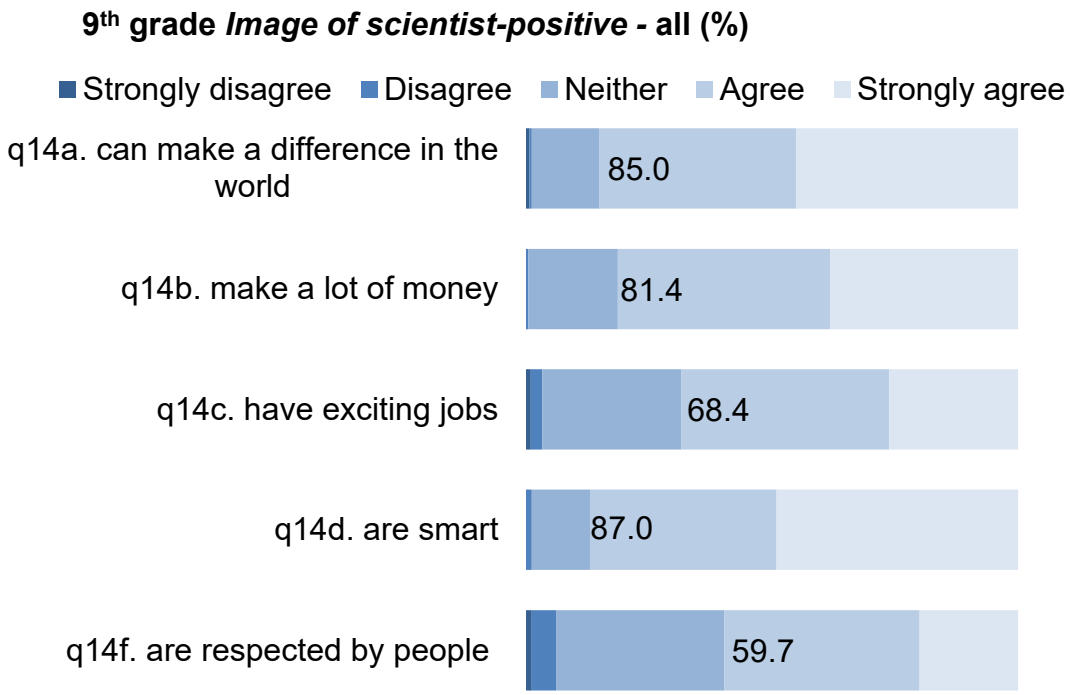


Figure A4.4. Item responses for the 9th grade component *Image of scientists-positive*.

Image of scientists-negative – 9th grade

The component capturing students' negative image of scientists was made up of the items: Scientists and people who use science in their jobs…

- q14e are weird.
- q14g spend most of their time working alone.
- q14h don't have many other interests in life.

Figure A4.5 shows item scores by percentage, with the percentage of the combined categories of 'agree' and 'strongly agree' displayed. The students mainly indicated ambivalence towards negative stereotypes of scientists, with only a minority of students holding negative images – consistent with the previous analysis of the student's positive image of scientists.

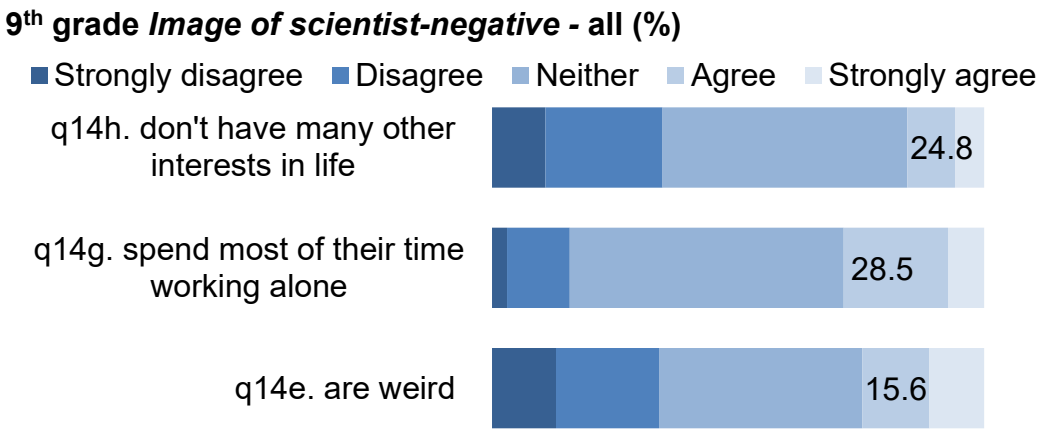


Figure A4.5. Item responses for the 9th grade component *Image of scientists-negative*.

APPENDIX 5 GENERATION OF SOCIOECONOMIC MEASURE

This appendix details the socioeconomic status (SES) measure generated for this study by employing a categorical principal components analysis (CatPCA) of survey data. First, the five input variables are explained. Next, the results and reliability analysis of the CatPCA for both East Los Angeles samples are presented. Lastly, the measure's correlations with its input variables are examined.

A5.1 Input variables

A single composite measure of socioeconomic status (SES) was generated from survey items theorized to be related to SES and is based upon the following five constructs.

A5.1.1 Home intellectual resources

This variable was initially conceptualized as a measure of "science capital" to be use for comparative purposes with respect to other studies into science aspirations (e.g., DeWitt et al., 2011, 2014; Gilmartin et al., 2006). It was included in the SES measure as it is a measure of capital. This variable is the sum score of three items: two binary responses to questions about access to the internet and possession of a home computer; the third a question about the number of books in the home[63]. Table A5.1 displays descriptive statistics for the East Los Angeles samples on this variable.

Table A5.1 Home intellectual resources scores for the East Los Angeles samples.

Home intellectual resources	6th grade (%)	9th grade (%)	Δ %
0	4.1	2.3	- 1.7
1	20.4	12.6	- 7.8
2	47.3	35.3	- 12.0
3	26.7	49.1	22.3

[63] As there was limited variability on this measure, this item was dichotomized from the original response scale of one to five to obtain a response of either 'many' or 'few to no' books in the home.

A5.1.2 Home ownership

A dichotomous indicator of whether the family owned their home (1) or rented or had some other arrangement (0). The home ownership rate in Los Angeles County is about 39 %, among the lowest in the United States (U.S. Census Bureau, 2015), and still lower in East Los Angeles. For example, in the Lincoln Heights area of East Los Angeles homeownership is approximately 23% (USC Sol Price Center for Social Innovation, 2017). Table A5.2 displays descriptive statistics for the East Los Angeles samples on this variable.

Table A5.2. Home ownership scores for East Los Angeles samples.

Home ownership	6th grade (%)	9th grade (%)	Δ %
0	68.3	72.0	3.7
1	19.9	25.7	5.8

A5.1.3 Home possessions

A composite score of eight binary responses (yes/no) to items asking about material assets of the student's home. The question from which the responses were drawn asked: Which of the following items do you have in your home?

- clothes dryer just for my family.
- electric dishwasher.
- electric garbage disposal.
- more than six rooms (not including bathrooms).
- more than one bathroom.
- a bedroom of my own.
- air conditioning in my whole home.
- and three or more cars.

Descriptive statistics for the East Los Angeles samples on this variable are displayed in Table A5.3.

Table A5.3. Home possessions scores for East Los Angeles samples.

Home possessions	6th grade (%)	9th grade (%)	Δ %
0	7.1	6.3	- 0.7
1	13.4	12.4	- 1.0
2	19.5	17.3	- 2.2
3	26.7	22.7	- 4.1
4	16.9	16.4	- 0.5
5	7.4	10.7	3.3
6	4.8	6.8	2.0
7	3.3	3.3	- 0.1
8	0.4	0.9	0.6

A5.1.4 Parent highest educational level

The highest educational level of the students' parents was reported by students and placed in one of three categories: (1) did not finish high school, (2) high school graduate, and (3) some college. Note that 'Some college' was decided upon as a category, rather than actual degree attainment, due to difficulties in determining the type of college and qualification from student survey responses. Table A5.4 displays descriptive statistics for the East Los Angeles samples on this variable. In the case of two parents, the higher of the two educational levels was selected (and used in the CatPCA).

Table A5.4. Parent highest education level for East Los Angeles samples.

Parent highest education level	6th grade (%)	9th grade (%)	Δ %
Did not finish high school	65.3	50.7	- 14.6
High School graduate	13.5	28.7	15.2
Some college	20.8	20.1	- 0.7

A5.1.5 Parent highest occupational prestige level:

The highest occupational level (job) of the students' parents was reported by the students from the 12 categories shown in Table A5.5. The table shows the recoding of the survey responses based upon a list of occupations by prestige by the National Opinion Research Center (NORC) (Smith & Son, 2014), a commonly used occupational prestige index (Hout, Smith, & Marsden, 2015) which includes over 800 occupations. The range of the prestige levels in some of the survey categories overlapped to some extent; consequently, the student responses were recoded into five more general categories: 'Not working' (1), 'Routine or Semi-routine' (2), 'Trade' (3), 'Manager or Supervisor' (4), and 'Professional' (5). The column labelled "NORC occupation" represents the mode value for each category. A sixth category was recoded as '99 - missing', with the understanding that missing values are treated as mode values in the CatPCA analysis discussed below. In the case of two parents, the higher of the two occupational levels was utilized. Table A5.6 displays descriptive statistics for the East Los Angeles samples on this variable.

Table A5.5 CatPCA coding for parent occupation.

Parent's job categories from survey	Survey Code	NORC occupation	NORC rating	SES code	SES category
Student	8	n/a	n/a	Not working	1
Does not work	9	n/a	n/a	Not working	1
Has a job that does not require any license (e.g., cleaner, restaurant worker, trash man)	1	Janitor	3	Routine or Semi-routine	2
Looks after people (e.g., child care, caregivers, hair stylist, secretary)	3	Hair stylist	3.8	Routine or Semi-routine	2
Works with customers (e.g., answers phones, sales assistant, customer service)	2	Receptionist	4.1	Routine or Semi-routine	2
Does skilled work with their hands (e.g., plumber, construction, mechanic, truck driver)	4	Plumber	4.7	Trade	3
Is a supervisor or manager	5	Manager of supermarket	4.9	Manager or Supervisor	4
Business owner	12	Owner of a day care center	4.9	Manager or Supervisor	4
Professional job (e.g., doctor, lawyer, teacher, accountant)	6	Public school teacher	5.8	Professional	5
Scientist or other job using science	7	Biologist	6.9	Professional	5
I don’t know	10			99	99
Some other job (write in):	11				

Table A5.6. Parent highest job level for East Los Angeles samples.

Parent highest job level	6th grade (%)	9th grade (%)	Δ %
1 - No job or student or IDK	26.9	12.9	-14.1
2 - Routine or Semi-routine	22.8	26.4	3.6
3 - Trade	35.6	35.7	0.1
4 - Manager or supervisor	4.6	7.2	2.6
5 - Professional	6.9	7.2	0.3
Missing	3.2	10.5	7.4

The five constructs presented above differ in levels of measurement (e.g., nominal for home ownership, ordinal for highest education of parents, and continuous for home possessions), complicating the generation of a single composite measure of socioeconomic status from them. Another consideration in generating a reliable and valid SES measure was that initial analysis of the survey data suggested nonlinearities between the continuous variables used in the SES composite measure. Consequently, in order to determine which theorized dimensions were most closely linked with students' SES, a categorical principal components analysis (CatPCA) was carried out. CatPCA is a type of nonlinear principal components analysis that is "particularly useful for data sets containing variables with different measurement levels (nominal, ordinal, or numeric) that might be nonlinearly related to each other" (Linting & van der Kooij, 2012).

A5.2 CatPCA results – East Los Angeles samples

The CatPCA was performed on both the 6th and 9th grade samples using the CATPCA 1.1 package in SPSS 22 (see Linting & van der Kooij, 2012). The scaling level for all variables was ordinal; all variables contributing to the solution were assigned equal weights of one. Data screening showed 55 case of missing data for the 6th grade sample and 42 cases of missing data for the 9th grade data; Treatment of missing data utilized the default passive option; employing this option ensures "that all available data are used in the analysis without fabricating extra data" (Linting & van der Kooij, 2012, p. 17). In other words, a person with missing data is not excluded from contributing to the solution as a whole, but only for the

variable(s) they have missing values on – for missing values, an extra analysis category of "Missing" is created.

A solution of one principal component for the 6th grade sample accounted for 33.52% of the variance in the SES measure, with a Cronbach's alpha of 0.50. Similarly, A solution of one principal component for the 9th grade sample accounted for 35.72% of the variance in the solution with Cronbach's alpha of 0.55[64]. Next, using component loadings on the extracted first principal component, shown in Table A5.7, a banded SES variable consisting of five quintiles was created, displayed in Table A5.8. Each banded SES measure was then examined with respect to its correlations with its five constituent variables.

Table A5.7. CatPCA loadings on first principal component.

Variable	6th grade loadings	9th grade loadings
Home intellectual resources	.441	.491
Home ownership	.467	.670
Home possessions	.709	.778
Parent highest educational level	.564	.611
Parent highest job level	.665	.340
Cronbach's alpha	.504	.550

[64] Although the internal consistency is somewhat low for both East Los Angeles samples, this was due to the restricted range of the East Los Angeles sample on the input variables. The reliability and validity of the measure is discussed in Appendix 7.

Table A5.8. Percentage of samples by socioeconomic quintile.

SES quintile	6th grade (%)	9th grade (%)
Quintile 1	18.6	21.5
Quintile 2	21.3	19.2
Quintile 3	20.0	19.4
Quintile 4	19.5	20.1
Quintile 5	20.6	19.9
Total	539	428

A5.3 SES component correlation matrices

Appendix Table A5.9 and Table A5.10 display the matrix of Spearman's correlations between the variables used in the CatPCA as input variables. All correlations between the SES measure and the input variables were significant, indicating strong linear relationships. For example, the largest correlation for the 6th grade SES measure was with *Home possessions* (ρ = .647), while the smallest was *Parent's highest job level* (ρ = .352).

Table A5.9. Bivariate Spearman correlations among 6th grade SES variables.

Variable	*SES q*	*HIR*	*HO*	*HP*	*PHEL*
SES quintile	-				
Home intellectual resources	.364**	-			
Home ownership	.502**	.050	-		
Home possessions	.647**	.166**	.200**	-	
Parent highest education level	.495**	.055	.069	.122**	-
Parent highest job level	.352**	0.037	0.057	.154**	.133**

Note: ** $p < .01$.

Table A5.10. Bivariate Spearman correlations among 9th grade SES variables.

Variable	*SES q*	*HIR*	*HO*	*HP*	*PHEL*
SES quintile	-				
Home intellectual resources	.448**	-			
Home ownership	.632**	.112*	-		
Home possessions	.710**	.236**	.357**	-	
Parent highest education level	.582**	.108*	.178**	.239**	-
Parent highest job level	.210**	.065	.103*	.092	-.029

Note: * $p < .05$, ** $p < .01$.

A5.4 Summary of Generation of Socioeconomic Measure

Using five input variables generated form student survey data, a CatPCA yielded a one component solution measuring student socioeconomic status, with adequate reliability. All correlations between the SES measure and the input variables were significant, indicating strong linear relations.

APPENDIX 6 MATERIAL FROM CHAPTER 5

A6.1 Data assessment and assumption testing – 6th grade regression analysis

A6.1.1 Assessing the 6th grade survey data

A valid regression model assumes that the variables used in the analysis have certain characteristics; violation of the assumptions impacts the interpretation of the model (Field, 2013; Tabachnik & Fidell, 2013). Assumptions associated with a linear regression analysis include: (1) ratio of cases to independent variables, (2) absence of outliers among the variables, (3) normally distributed variables, (4) bivariate linearity between the independent and dependent variables, and (5) absence of multicollinearity. These assumptions were assessed for the 6th grade survey data and the results are reported below.

A6.1.1.1 Ratio of cases to independent variables

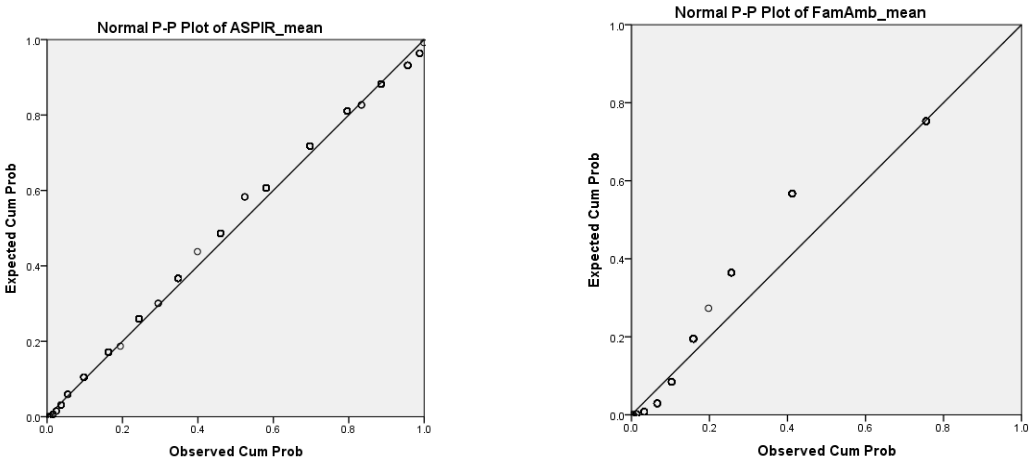
A valid regression model requires a sufficient case-to-independent variables ratio. A commonly used ratio for testing the number of cases, N, for the regression is $N \geq 50 + 8m$ (where *m* is the number of independent variables), while for testing individual predictor variables $N \geq 104 + 8m$ (Tabachnik & Fidell, 2013, p. 123). These formulas assume a medium effect size relation (i.e., how well predictors predict the outcome) between the independent variables and the dependent variable, together with error probabilities of $\alpha = .05$ and $\beta = .20$. The overall fit and contribution of individual predictors were both of interest in this analysis. In such situations Tabachnik and Fidell (2013) recommend that the larger of the two ratios, $N \geq 104 + 8(9) = 176$, be applied. As the sample size in this analysis is N = 539, this assumption is met.

A6.1.1.2 Outliers among the variables

Extreme cases in the data can greatly impact the regression solution (Field, 2013; Tabachnik & Fidell, 2013). Tabachnik and Fidell (2013) suggest initially screening the data using frequencies to detect scores far from the mean; this check was performed on the sample data – no unusual cases were detected. Outliers and influential cases were checked further using statistical methods after an initial regression run (see Section A6.1.2 below).

A6.1.1.3 Normally distributed variables

Multiple regression analyses assume that continuous variables possess normal distributions (Field, 2014; Tabachnik & Fidell, 2013). This assumption can be tested in several ways including visual inspection of data plots, skew and kurtosis statistics, and probability-probability plots (P-P plots) (Field, 2013). The P-P plot is a graph of the cumulative probability of a variable against the cumulative probability of a particular distribution; a normal distribution in this case. Data with a perfect normal distribution will fall exactly on the diagonal; deviations from the diagonal indicate deviations from a normal distribution (Field, 2013). Figure A6.1 displays the P-P plots for the components *Aspirations in science* and *Family ambitions* from SPSS 22 output. As seen in the figure, the *Aspirations in science* variable exhibits sufficient normality, while *Family ambitions* is clearly non-normal. As a result of its non-normal distribution, *Family ambitions* was dichotomized for use in the multiple regression analysis. All other variables used in the 6th grade multiple regression were found to be normally distributed.



(a) (b)

Figure A6.1. P-P plots for the components 6th grade (a) *Aspirations in science* and (b) *Family ambitions* (SPSS 22 output).

A6.1.1.4 Independent variables exhibit bivariate linearity with the dependent variable

If the assumption of the linearity between the dependent variable and the independent variables is violated, the estimates of the regression (e.g., regression coefficients, standard errors, and tests of statistical significance) may be biased (Field, 2013). This assumption can be checked by (a) inspecting the correlation matrix of variables and (b) through examination of scatter plots for non-linear relations (Field, 2013). Inspection of the 6th grade component correlation matrix (Table 4.11) did not indicate any non-linear relations among the variables.

Scatter plots graphically display the relation between two variables. For example, Figure A6.2 shows a positive linear trend between the independent variable *Experience of school science* and the dependent variable *Aspirations in science*. Inspection of the matrix of scatter plots indicated sufficient bivariate linearity for all predictors with the dependent variable, *Aspirations in science*.

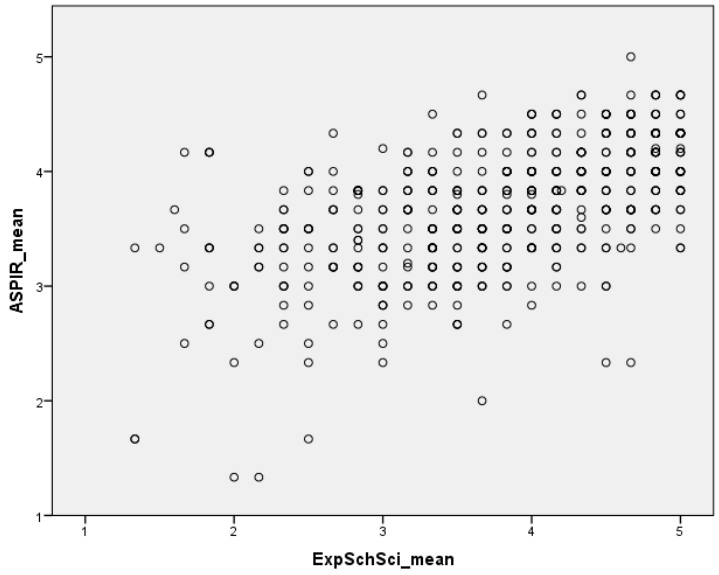


Figure A6.2. Scatterplot of *Experience of school science* versus *Aspirations in science* (SPSS 22 output).

A6.1.1.5 Absence of multicollinearity

Multicollinearity refers to the assumption that independent variables are not highly correlated with one another; if the variables are highly correlated it is possible that one independent variable is nearly a linear combination of others (Tabachnik & Fidell, 2013). If multicollinearity exists among the variables, the regression will not accurately associate variance in the dependent variable with the corresponding independent variable – possibly invalidating inferences made from the model. Commonly used methods of determining whether multicollinearity is an issue include examining (a) the correlation matrix of the independent variables (Table 4.12) and (b) utilizing statistics of the eigenvalues of the data matrix, including variance inflation factors (Tabachnik & Fidell, 2013). In examining the correlation matrix of variables, one attempts to "see if any highly correlate (above .8 or .9) a good 'ball park' figure" (Field, 2013, p. 224). Examination of Table 4.12 showed no correlations among the independent variables greater than .653, with the majority less than .400.

The variance inflation factor (VIF) indicates whether a predictor variable has a strong linear relation with other predictors (Tabachnik & Fidell, 2013). Values greater than one indicate some multicollinearity, with 10 and greater "a cause for concern" (Field, 2013, p. 325). As an example, Table A6.1 displays the SPSS output for the VIF of the variable *Image of scientist-positive,* with the other nine components used as independent variables in a simple regression. The majority of the VIF multicollinearity statistics are less than 2.00, with the largest at 2.729 for *Experience of school science* – well below the "cause of concern" value of 10.

Model		Collinearity Statistics	
		Tolerance	VIF
1	ASPIR_mean	.533	1.877
	ExpSchSci_mean	.366	2.729
	FamAmb_mean	.824	1.214
	FamSci_mean	.553	1.809
	ImaNeg_mean	.879	1.138
	OutSci_mean	.617	1.620
	PeeAtt_mean	.600	1.667
	PeeOri_mean	.798	1.253
	SelCon_mean	.538	1.858

a. Dependent Variable: ImaPos_mean

Table A6.1. VIF values for *Image of scientist-positive* (SPSS 22 output).

A6.1.2 Assessing the 6th grade regression model – fit

A6.1.2.1 Outliers – distance

In order to determine if any cases substantially biased the regression model, multivariate outliers were examined. Cases that have large standardized residuals (residuals divided by an estimate of their standard deviation) can be used to identify an outlier (Field, 2103). A normally distributed sample of standardized residuals would be expected not to have (a) more than 5% of cases with absolute values greater than 1.96 and (b) more than 1% of its absolute values greater than 2.58 (Field, 2013, p. 345). Casewise diagnostics of the 6th grade sample showed 3.9% (21 out of 536) of its standardized residuals greater than +/- 1.96, within 2.3% of what was expected. As well, 1.5% (8 of 536) of the standardized residuals were greater than 2.58, very close to the expected 1% value.

The most extreme standardized residual was identified (3.422) and examined further. This case was a second-generation boy who attended Mendel Middle School, spoke mainly Spanish at home, was in the second SES quintile, and had a mean score of 4.50 (out of five) on the *Aspirations in science* measure – with a predicted score of 3.56. The cases with the next three

highest standardized residuals were examined as well. The four cases all had reasonable responses ranges on the survey items; thus, no case was removed from subsequent analyses.

A6.1.2.2 Influential cases – leverage

The leverage measure was examined to determine whether any cases exerted undue influence over the model as a whole and in this way caused instability within the solution. The leverage statistic (range 0 -10) gauges the unusualness of a pattern of independent variables, without respect to the dependent variable (Field, 2013). Three times the average leverage value of (k+1)/n is suggested as a cut-off point for identifying cases that have undue influence on a model (Field, 2103, p. 307). A sample size of N = 530 and k = 25 predictors yields a cut-off point of 3 x .05 = .15. The highest leverage case was .132; this student had a mean *Aspirations in science* score of 4.33 and a predicted score of 3.95. Further investigation showed that this student did not appear to have a particularly unusual combination of independent variable scores. Consequently, no cases were identified as exerting undue influence on the model.

A6.1.2.3 Influential cases – influence

Cases that could be highly influential on the intercept or the regression line were also examined. Cook's distance (Cook's D) is a measure of the influence of such cases; values greater than 1.00 "may be cause for concern" (Field, 2013, p. 306). It is proportional to the sum of the squared differences between predictions made with all cases in the analysis, and predictions made excluding the case in question (Field, 2013). If predictions differ greatly, then the case is considered influential. Examination of residual statistics show a maximum Cook's distance of .021, well below the criteria for concern.

Examined together, the outliers and influential cases examined here did not appear to share characteristics in common and, thus, be systematically different from other cases in the regression analysis; they are considered to be attributable to normal variation. Consequently, this set of diagnostics show that the regression model has not been unduly influenced by a subset of unusual cases. The remaining assumptions of the regression analysis are discussed next.

A6.1.3 Assessing the 6th grade regression model – generalization

In order to generalize the regression model beyond the sample to the population, all underlying assumptions of the multiple regression analysis must be verified. In this subsection the (1) homoscedasticity of residuals, (2) independence of residuals, (3) linearity of residuals, and (4) normality of residuals are examined.

A6.1.3.1 Checking assumptions – homoscedasticity of residuals

The assumption that the variance of the independent variables at each level should be constant is referred to as homoscedasticity. Violation of this assumption affects standard errors, which in turn affects significance values. Analysing residuals scatterplots allows for the evaluation of homoscedasticity (Tabachnik & Fidell, 2013). Figure A6.3 is a scatterplot of the standardized predicted values of the dependent variable based on the model versus the standardized residuals. Inspection of the figure reveals that the residuals are very uniformly distributed through each level of the predicted value between -2 and +2. Although the residuals do appear to have less spread below -2, there are only about eight cases in this domain.

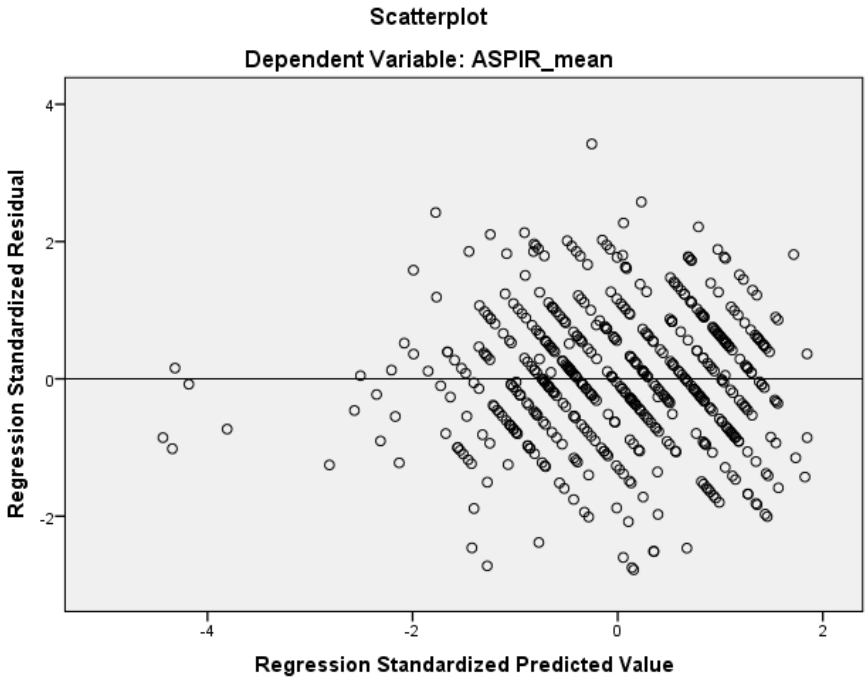


Figure A6.3. Plot of the standardized residuals vs. standardized predicted values of the dependent variable for the 6th grade sample (SPSS 22 output).

A6.1.3.2 Checking assumptions – independence of residuals

Independence of residuals is the assumption that residual terms for any two measurements should be uncorrelated. This can be checked with the Durbin-Watson test, which tests for serial correlations between residuals and varies between 0 and 4 (Field, 2013). The Durbin-Watson statistic was determined to be 1.954, quite close to the value of 2.00 that indicates that the residuals are uncorrelated (Field, 2013).

A6.1.3.3 Checking assumptions – linearity of residuals

The assumption of the linearity of residuals can be assessed using a scatterplot of the residuals and the predicted values of the regression (Field, 2013), such as Figure A6.4. In such a plot, the regression line is expected to be the straight horizontal line through the mean of the residuals, y = 0. Fitted on the plot is the lowess line, which represents the nonparametric best fitting line that does not impose the requirement of linearity. The regression line and the lowess line should overlap if there is no departure from linearity in the data. Here the lowess line lies very close to the regression line, suggesting there is no departure from linearity.

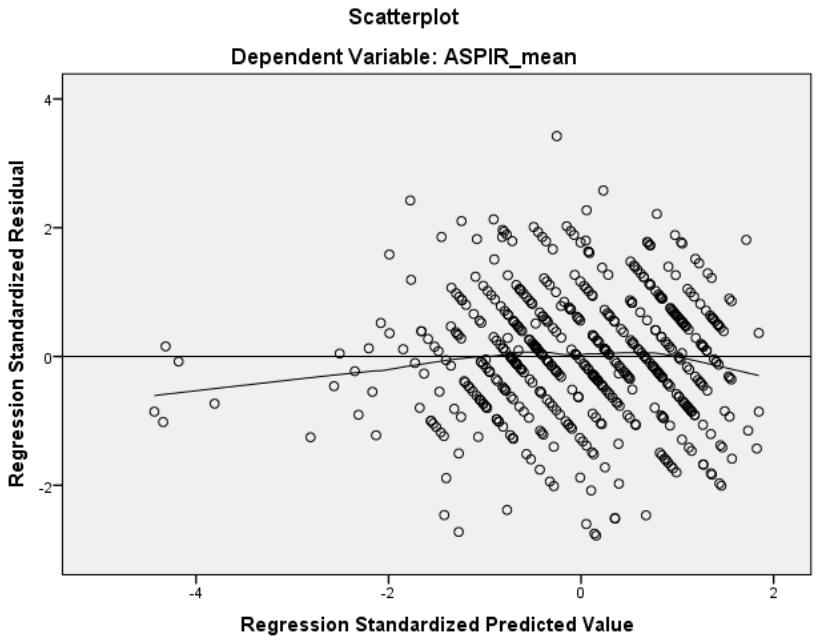


Figure A6.4. Lowess line on the plot of the standardized residuals vs. standardized predicted values of the dependent variable for the 6th grade sample (SPSS 22 output).

A6.1.3.4 Checking assumptions – normality of residuals

The assumption that the residuals are randomly, normally distributed variables with a mean of 0 is checked by examination of the normal probability - probability plot (Field, 2013). This plot displays the cumulative probability of the variable against the cumulative probability of the normal distribution. Figure A6.5 is the probability - probability plot (P-P plot) of the standardized residuals of the dependent variable, *Aspirations in science*. In the figure, the straight line in the plot represents a perfect normal distribution. Inspection of this plot confirms the residuals are distributed sufficiently normal.

As demonstrated in this appendix, the principal assumptions of a multiple linear regression analysis were satisfied, validating the 6th grade model.

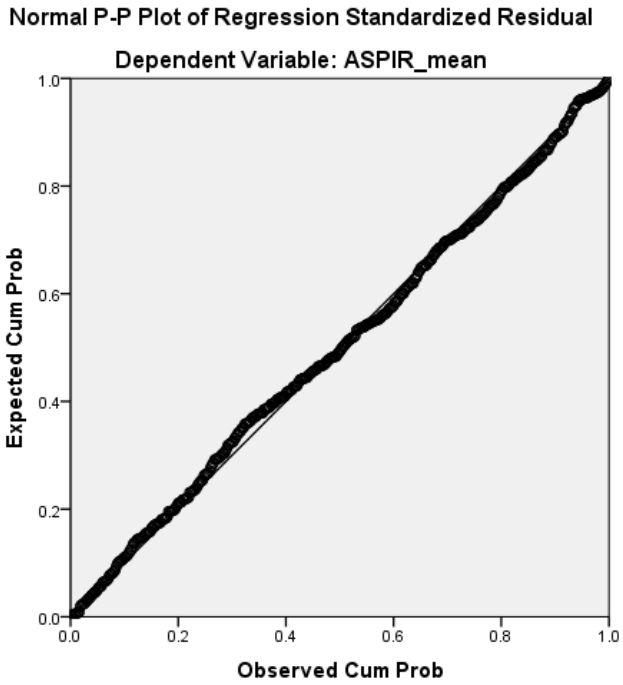


Figure A6.5. Normal P-P plot of standardized residuals for 6th sample (SPSS 22 output).

A6.2 Data assessment and assumption testing – 9th grade regression analysis

This section presents the data assessment and assumption testing of the hierarchical multiple regression analysis of the 9th grade survey data. Specific procedures were detailed above for the 6th grade data. Consequently, the results of the 9th grade data assessment and assumption tests are concisely presented here.

A6.2.1 Assessing the 9th grade survey data

A6.2.1.1 Ratio of cases to independent variables

The ratio of cases to independent variables suggested by Tabachnik and Fidell (2013) for multiple regression is $N \geq 50 + 8m$ (m is the number of independent variables), while for testing individual predictor variables $N \geq 104 + 8m$ (p. 123). The overall fit and contribution of individual predictors were both of interest in this analysis. In such situations Tabachnik and Fidell (2013) recommend that the larger of the two ratios, $N \geq 104 + 8 (10) = 184$. This assumption is met given that the sample size in this analysis is N = 428.

A6.2.1.2 Outliers among the variables

The check for outliers was performed following Tabachnik and Fidell's (2013) suggestion to initially screen the data using frequencies to detect scores far from the mean; no unusual cases were detected among the 9th grade data. Outliers and influential cases were also tested after an initial regression run using further statistical methods (see Section A6.2.2).

A6.2.1.3 Normally distributed variables

The assumption of normally distributed variables was checked by visual inspection of P-P plots. For example, Figure A6.6 displays P-P plots for the 9th grade variables *Aspirations in science* and *Family ambitions*. Inspection of the P-P plots of the eleven variables to be used in the planned multiple regression showed one evident non-normal distribution: *Family ambitions* (Figure A6.6b). As with the 6th grade sample, the *Family ambitions* variable was dichotomized for use in the multiple regression analysis.

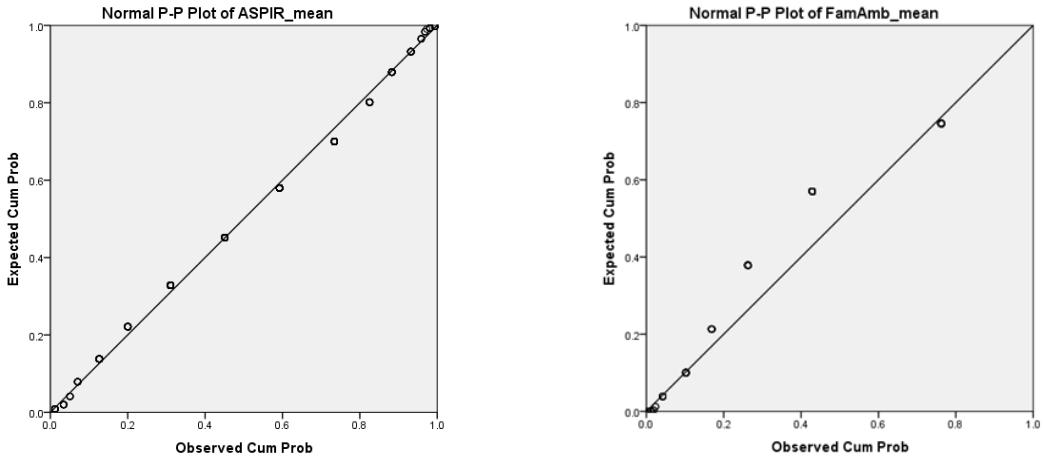


Figure A6.6. P-P plots for the 9th grade components *Aspirations in science* and *Family ambitions* (SPSS 22 output).

A6.2.1.4 Independent variables exhibit bivariate linearity with the dependent variable

Inspection of the 9th grade component correlation matrix (Table 4.14) suggested linear relations among the variables. Examination of scatter plots also indicated that the independent variables exhibit bivariate linearity with the dependent variable. For example, Figure A6.7 shows a positive linear trend between the independent variable *Experience of school science* and the dependent variable *Aspirations in science*. Inspection of the matrix of the scatter plots for the eleven components showed sufficient bivariate linearity of all components with the dependent variable, *Aspirations in science*.

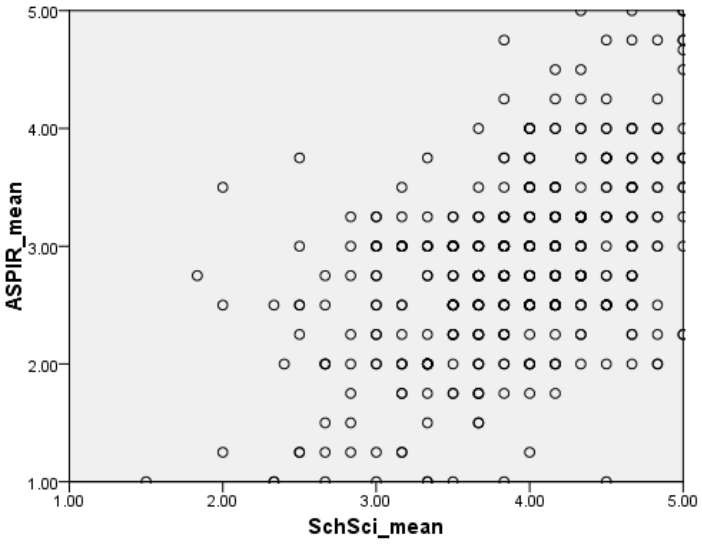


Figure A6.7. Scatterplot of 9th grade *Experience of school science* versus *Aspirations in science* (SPSS 22 output).

A6.2.1.5 Absence of multicollinearity

Evaluating multicollinearity in the data was accomplished by (a) examining the 9th grade correlation matrix of the independent variables (see Table 4.14) and (b) using statistics of the eigenvalues of the data matrix, specifically variance inflation factors (Tabachnik & Fidell, 2013). Table 4.14 shows that the largest correlation is between *Peer attitudes to science* and *Peer orientation to science* (r = .611), with the majority less than .400 – well below Field's (2013) suggested maximum of .8 (p. 224).

Recall that variance inflation factor (VIF) values greater than one indicates some multicollinearity, with 10 being a cause for concern (Field, 2013, p. 325). For the 9th grade sample all VIF values were less than 10. As an example, Table A6.2 displays the SPSS output for the VIF of the variable *Family attitude to science,* with the other ten components used as independent variables in a simple regression. The majority of the VIF multicollinearity statistics are less than 2.00, with the largest at 2.259 for *Experience of school science*, well below the concern threshold of 10.

Model		Collinearity Statistics	
		Tolerance	VIF
1	ASPIR_mean	.622	1.607
	FamAmb_mean	.810	1.235
	SchSci_mean	.443	2.259
	SelCon_mean	.545	1.834
	OutSci_mean	.822	1.217
	PeeOri_mean	.586	1.707
	PeeAtt_mean	.522	1.915
	ImaPos_mean	.779	1.283
	ImaNeg_mean	.927	1.079
	FamInv_mean	.579	1.728

a. Dependent Variable: FamSci_mean

Table A6.2. VIF values for 9th grade *Family attitudes to science* (SPSS 22 output).

A6.2.2 Assessing the 9th grade regression model – fit

A6.2.2.1 Outliers – distance

In order to evaluate whether any cases substantially biased the model, multivariate outliers were examined. A normally distributed sample of standardized residuals would be expected not to have (a) more than 5% of cases with absolute values greater than 1.96; and (b) more than 1% of its absolute values greater than 2.58 (Field, 2013, p. 345). Casewise diagnostics of the 9th grade data showed 6% (25 out of 417) of its standardized residuals were greater than +/- 1.96, within 1% of what was expected. As well, 1.6% (7 of 417) of the standardized residuals were greater than 2.58, very close to the expected 1% value.

The most extreme case (-3.29) was identified and examined in depth: a third-generation boy who attended Gibbs High School, spoke Spanish once in a while at home, located in the third SES quintile, and had a mean score of 1.00 (out of five) on the *Aspirations in science* measure with a predicted score of 2.95. The cases with the next three highest standardized residuals were examined as well. All four cases appeared to have reasonable ranges of responses, and consequently all cases were retained in subsequent analyses.

A6.2.2.2 Influential cases – leverage

The leverage measure was utilized to determine whether any cases exerted undue influence over the regression model as a whole, causing instability in the solution. Three times the average leverage value of (k+1)/n is suggested as the cut-off point for identifying cases that have undue influence (Field, 2103, p. 307). With k = 26 predictors and a sample size of N = 428 produces a cut-off point of 3 x .06 = .18. Five cases were identified as being potentially influential cases, with a high case of .286. This student had an *Aspirations in science* score of 1.00 and a predicted score of 1.63. Further analysis showed that this student did not possess an unusual combination of variable scores; consequently, the student was not considered to exert undue influence on the 9th grade model.

A6.2.2.3 Influential cases – influence

Cases that might be highly influential on the intercept or the regression line were examined, recalling that values greater than 1 "may be cause for concern" (Field, 2013, p. 306). Examination of residual statistics showed a maximum Cook's distance of .062, well below the criteria for concern.

Examined together the outliers and influential cases did not appear to share characteristics in common and as a result be systematically different from other cases in the 9th grade regression analysis; their characteristics are thought to be attributable to normal variation. Thus, this set of diagnostics demonstrates that the regression model has not been unduly influenced by a subset of cases. The remaining assumptions of the 9th regression analysis are presented next.

A6.2.3 Assessing the 9th grade regression model – generalization

A6.2.3.1 Checking assumptions – linearity of residuals

Figure A6.8 is the scatterplot of the residuals and the predicted values of the regression, used to check the assumption of linearity of residuals (Field, 2013). As seen in the figure, the lowess line is situated very close to the regression line and, consequently, does not suggest a departure from linearity.

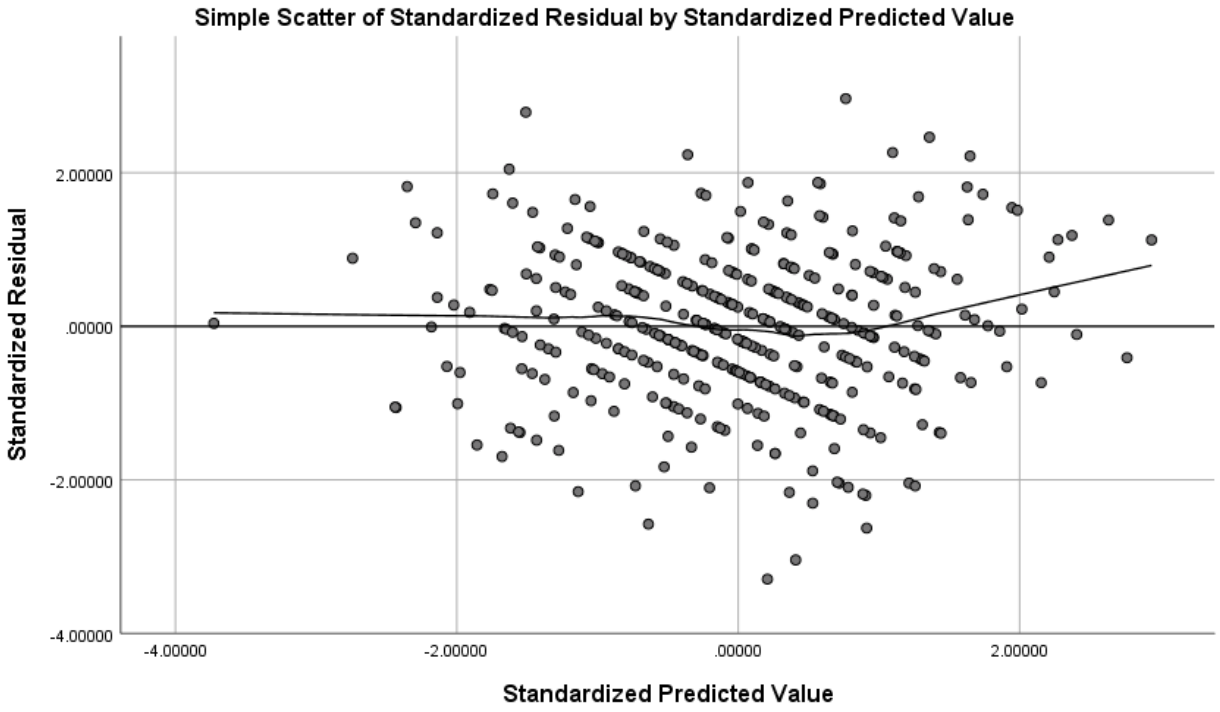


Figure A6.8. Lowess line on the plot of the standardized residuals vs. standardized predicted values of the dependent variable for the 9th grade sample (SPSS 22 output).

A6.2.3.2 Checking assumptions – homoscedasticity of residuals

Figure A6.9 is the scatterplot of the standardized predicted values of the dependent variable based on the model versus the standardized residuals. Homoscedasticity is sufficient, as inspection of the figure shows that the residuals are very uniformly distributed through each level of the predicted value between -2 and +2.

A6.2.3.3 Checking assumptions – independence of residuals

The independence of the residuals is assumed: the Durbin-Watson statistic was found to be 2.064, close to the value of 2 which indicates that the residuals are uncorrelated (Field, 2013).

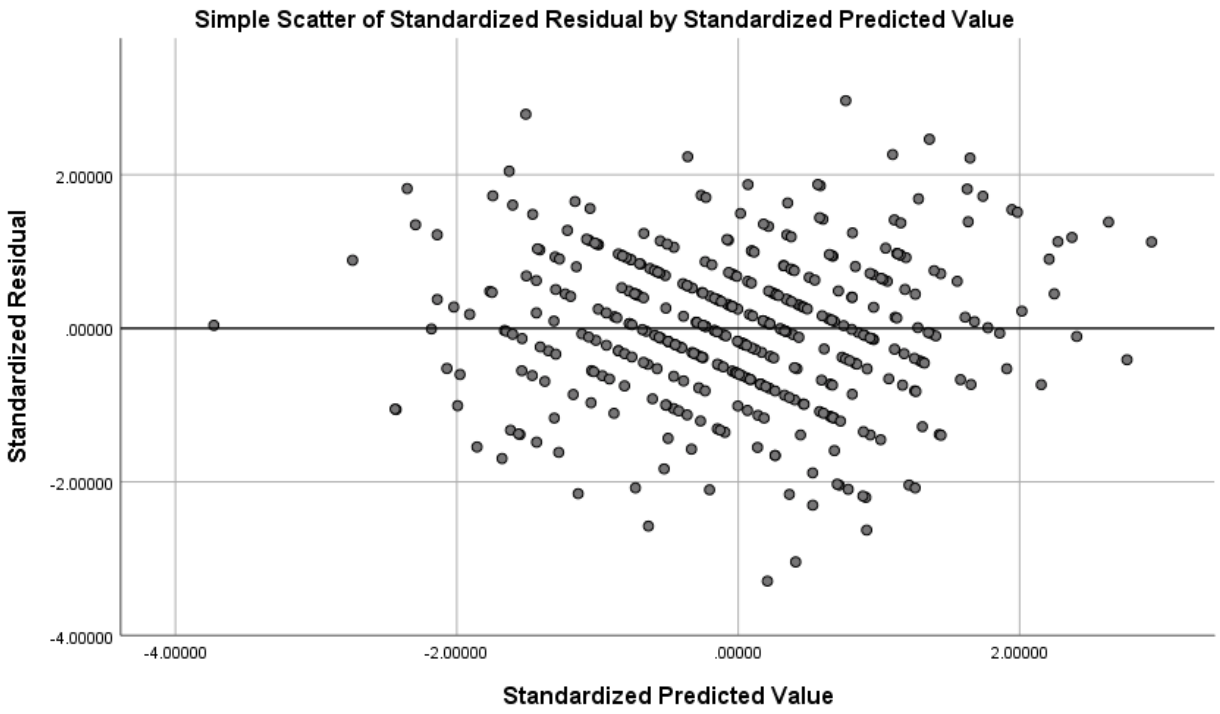


Figure A6.9. Plot of the standardized residuals vs. standardized predicted values of the dependent variable for the 9th grade sample (SPSS 22 output).

A6.2.3.4 Checking assumptions – normality of residuals

Figure A6.10 is the probability - probability plot (P-P plot) of standardized residuals of the dependent variable *Aspirations in science*. In the figure, the straight line in the plot represents a perfect normal distribution. Inspection of this plot suggests normal distribution of the residuals.

As demonstrated in this appendix, the principal assumptions of a multiple linear regression analysis were satisfied, validating the 9th grade model.

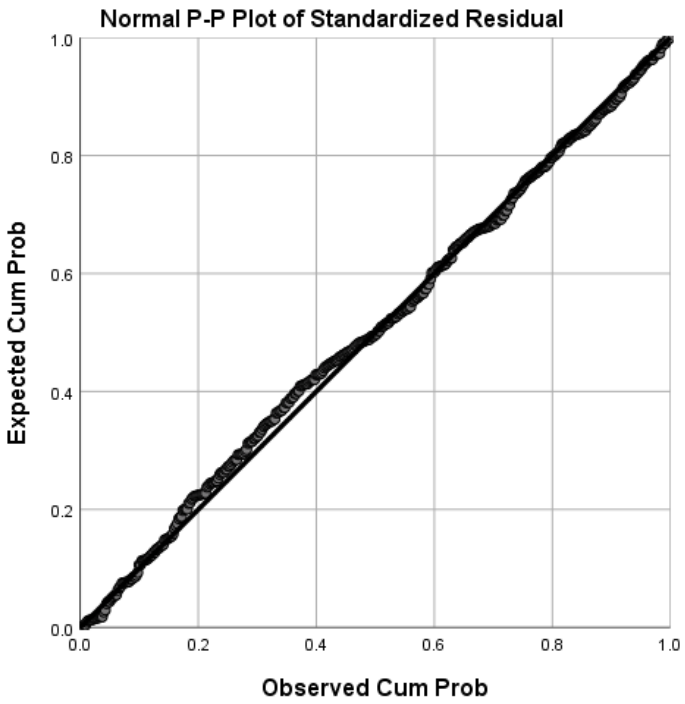


Figure A6.10. Normal P-P plot of standardized residuals for 9th sample (SPSS 22 output).

APPENDIX 7 EXTENDED 6th GRADE SAMPLE

This appendix details the acquisition and analysis of the extended 6th grade sample data. In order to provide additional context for and understanding of the East Los Angeles sample analysis, survey data was collected from three middle schools in neighbourhoods adjacent to East Los Angeles. More specifically, data was collected from the extended sample to (1) get some indication of ethnic differences among science aspirations, (2) establish whether restriction of range in the socioeconomic measure accounted for the limited reliability of the measure in the East Los Angeles samples, and (3) whether the effect of socioeconomic status on science aspirations increased in the extended sample, relative to the East Los Angeles samples.

The results of the regression analysis predicted Latino students to hold significantly higher science aspirations than White students. The results suggest the limited reliability of the SES measure was due to the restriction of range of the measure within the East Los Angeles sample. The results also demonstrated that the SES measure effectively predicted science aspirations within the extended sample. This appendix begins with a description of the methods utilized to collect the data. Then, the data analysis is presented. This appendix concludes with an evaluation and discussion of the SES measure.

A7.1 Methods of the 6th-Extended sample data

A7.1.1 Participating schools, teachers, and students

Participating schools

The setting of this study was extended to include several neighbourhoods adjoining East Los Angeles. Five middle schools were contacted – four agreed to participate; however, time and resource constraints allowed for data collection at just three additional middle schools. Figure A7.1 shows the approximate location of the three participating middle schools, relative to East Los Angeles. The neighbouring schools provided a sample of students with a wide range of demographic characteristics, supplying useful context for the East Los Angeles samples (95% Latino, mainly low socioeconomic status). Note that, although they are located adjacent to East Los Angeles, the three schools varied considerably with respect to socioeconomic

status and ethnic makeup. For example, while SP Middle School (SPMS) and Halley Middle School (in East LA) are located just 2.9 miles apart, the average home price in the neighbourhood of SPMS ($1,187,500) was nearly double that of the area surrounding Halley MS ($604,100) (Zillow, Inc., 2016).

Table A7.1 displays selected characteristics[65] of the three inclusive public middle schools where additional data collection occurred. Note that SPMS had similar proportions of Latino (25%), Asian (34%) and White (29%) students. In contrast, the student population of OMS was comprised mainly of Latino (67%) and Black (32%) students and is located in an area of extremely high deprivation and crime. JMS lies between SPMS and OMS on the socioeconomic and ethnic diversity spectrums.

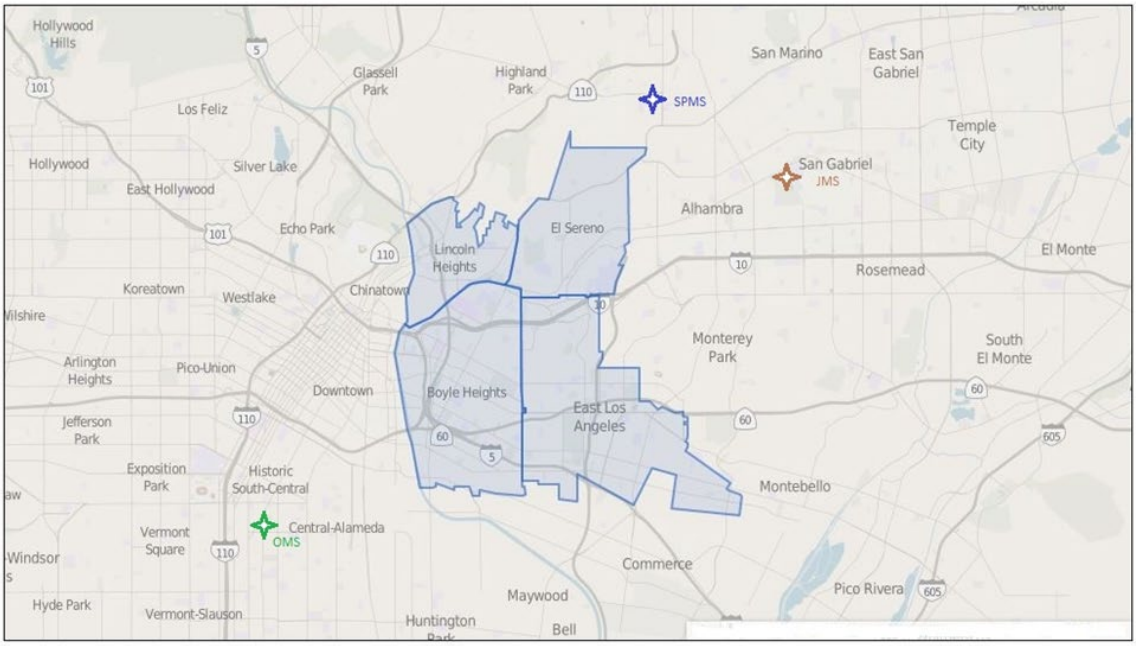


Figure A7.1. Location of additional schools relative to East Los Angeles, California. (Adapted from Los Angeles Times, 2015b).

[65] The two columns, “ELA standard met” and “Math standard met”, display the percentage of students considered proficient in English and mathematics by California standardized testing the school year the sample was collected (2015-2016).

Table A7.1. Selected characteristics and ethnic makeup of extended sample middle schools in 2015-2016.

School[a,b]	Total (N)	6th grade (N)	ELA standard met (%)	Math standard met (%)	Free Lunch (%)	English Learners (%)	Ethnicity (%)
JMS	1212	399	63	48	53.6	27.9	36-Latino 52 -Asian 1-Black 6-White
OMS	572	91	8	3	90.9	29.0	67-Latino 32 -Black 1-Other
SPMS	1098	363	81	77	15.8	4.6	25-Latino 34 -Asian 2-Black 29-White

Notes: [a]All school names are pseudonyms.
[b]All data sourced from Education Data Partnership (2019).

Participating teachers and students

Once access was granted for a school, a list of 6th grade level science teachers was obtained through administration sources at the school site; the intent was to randomly select teachers for participation in the study. However, the school principal selected the participating teachers at all three schools. Once a teacher agreed to participate, all the science classes taught by that teacher were asked to take part in the survey. Participating teachers were asked to distribute information sheets and consent letters (opt-out) to their students (see Appendix 2) approximately one week before the scheduled survey date.

A7.1.2 Data collection procedures

Additional survey data was successfully collected from an extended sample of middle school students (N = 284) attending schools in neighbourhoods adjoining East Los Angeles using the methods detailed in Chapter 3. Table A7.2 provides basic descriptive information about the survey population from each of the participating schools; the 6th-East Los Angeles sample is provided for reference. The total number of participants in the Extended 6th grade sample provided sufficient degrees of freedom for the robust estimation of population parameters and frequency distributions, as well as coefficients on independent variables of interest in inferential models, which are detailed in the analysis section presented next.

Table A7.2. Extended 6th grade survey counts by school.

School[a]	6th grade (N)	Sample (N)	Boys (N)	Girls (N)	Sample Ethnicity[b] (%)
East LA MS	8345	539	247	292	94.5 - Latino 0.6 - Asian 0.2 - Black 2.2 - White
JMS	399	93	43	50	21.5 - Latino 62.4 - Asian 2.2 - Black 2.2 - White
OMS	91	44	27	17	62.4 - Latino 0.0 - Asian 25.0 - Black 2.3 - White
SPMS	363	147	78	67	11.6 - Latino 25.2 - Asian 2.7 - Black 32.7 - White
Total (excluding East LA sample)		284	148	134	

Note: [a]All school names are pseudonyms.
[b]Column does not sum to zero.

A7.2 Data analysis of the 6th-Extended sample data

A multiple hierarchical regression analysis was carried out on the data collected from 284 6th grade students additional to the main study sample, together with the 539 East Los Angeles 6th grade students. The analysis[66] was conducted with three objectives. One, to get some indication of ethnic differences among science aspirations. Two, to establish whether restriction of range in the socioeconomic measure accounted for the limited reliability of the measure in the East Los Angeles samples. Three, to determine whether the effect of

[66] Details of the analysis in this appendix are concisely stated, as comprehensive descriptions are presented in Chapter 4 and Chapter 5 of this thesis.

socioeconomic status on science aspirations increased in the extended sample, relative to the East Los Angeles samples.

This section begins with an overview of the variables used in the regression analysis. Then, a summary of the regression data assessment and assumption testing is presented. Next, the results of the hierarchical multiple regression analysis are presented and assessed. Last, the regression model is analysed relative to the East Los Angeles 6th grade sample.

A7.2.1 Variables from the 6th-Extended survey data

A7.2.1.1 Student background characteristics and ethnicity

Background characteristics theorized to be related to *Aspirations in science* and included in the 6th-Extended regression analysis were ethnicity, gender, generation of immigration, home language, school attended, and socioeconomic status (SES). In order to highlight neighbourhood differences, the six East Los Angeles middle schools were aggregated into the category 'East LA schools' for this analysis (details of the East Los Angeles sample are presented in the main thesis). For example, Figure A7.2 displays the SES quintile distribution by school, with the percentage belonging to Quintile 5 (highest SES quintile) shown within the bar. As seen in the figure, less than 5% of the East LA sample are located in the highest quintile, while more than 70% of the SPMS sample are located in Quintile 5.

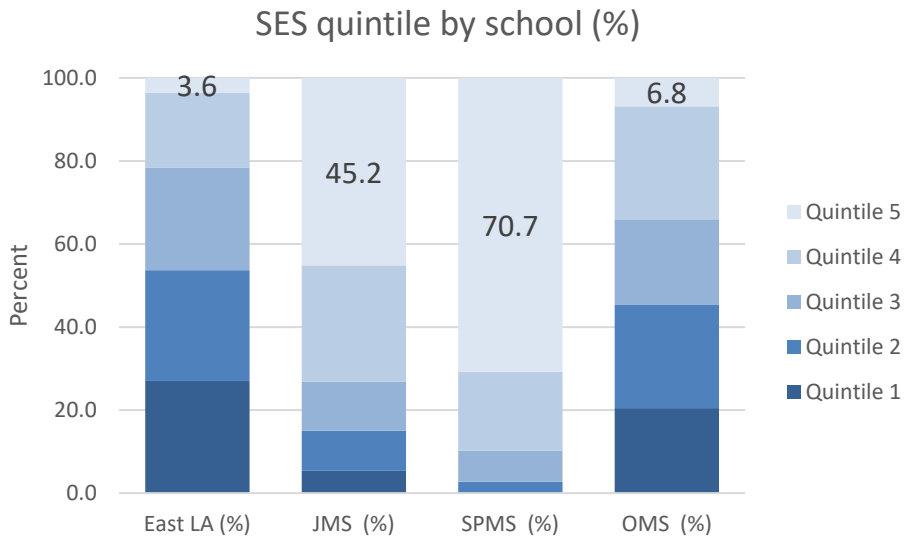


Figure A7.2. Socioeconomic quintile distribution within 6th-Extended schools.

The variation in the 6th-Extended survey demographic data provided the opportunity to include ethnicity as a student background variable in the analysis. Using self-reported information, the students were classified into one of five ethnic categories: Asian, Black, Latino, White, and Other. Figure A7.3 shows the ethnic distribution within the schools. As seen in the figure, SPMS was the most diverse of the schools, while the East LA aggregate was the least diverse. Detailed information on the other background characteristics used in this analysis are located in Section 4.5 of the main thesis, while the CatPCA procedure used to extract the SES measure is presented in Appendix 5.

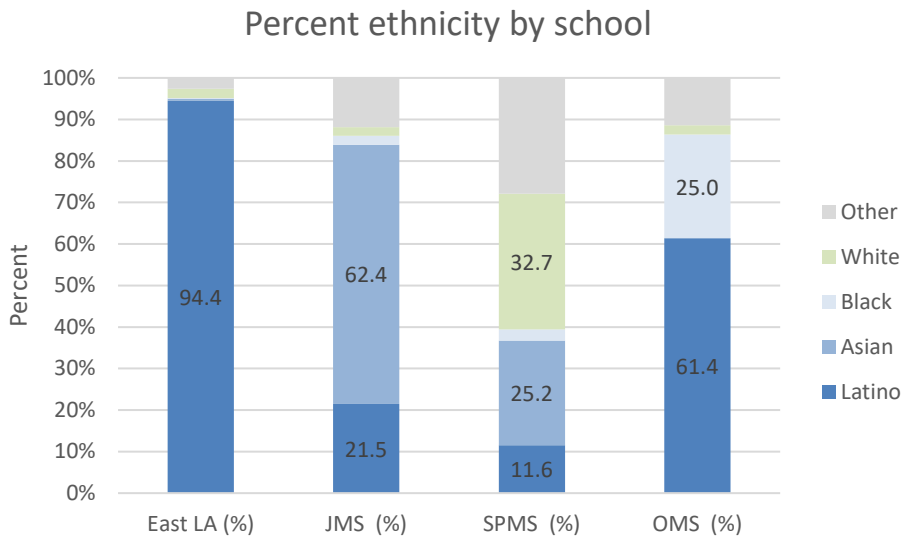


Figure A7.3. Ethnic distribution within 6th-Extended schools.

A7.2.1.2 Attitudinal components

The nine attitudinal components that emerged from the principal components analysis (PCA) of the 6th-East LA survey data were included in the regression analysis (see Chapter 4). Table A7.3 displays mean component scores (out of five) by school, with the standard deviation (SD) shown in parentheses.

A7.2.1.3 Aspirations in science

The outcome variable of the regression analysis, *Aspirations in science*, was generated from the principal components analysis of the 6th-East LA survey data. For reference, Table A7.4 displays mean scores on *Aspirations in science* by student groupings. Correlations between *Aspirations in science* and independent variables used in the regression analysis are examined next.

Table A7.3. Attitudinal component mean scores by 6th-Extended school (Scale 1-5).

Attitudinal component	East LA score (*SD*)	JMS score (*SD*)	OMS score (*SD*)	SPMS score (*SD*)
Aspirations in science	3.10 (0.92)	3.15 (0.82)	3.17 (0.84)	3.21 (0.89)
Experience of school science	3.79 (0.89)	4.01 (0.64)	3.82 (0.67)	4.07 (0.59)
Family ambition	4.74 (0.39)	4.75 (0.33)	4.74 (0.35)	4.60 (0.42)
Family attitudes to science	3.53 (0.86)	3.32 (0.71)	3.58 (0.86)	3.74 (0.78)
Image of scientists-negative	3.00 (0.81)	2.72 (0.79)	2.97 (0.71)	2.42 (0.80)
Image of scientists-positive	4.14 (0.64)	4.08 (0.51)	4.33 (0.52)	4.09 (0.53)
Outside of school science	3.00 (1.05)	2.67 (0.97)	2.90 (1.06)	3.24 (0.92)
Peer attitudes to science	2.90 (0.95)	3.24 (0.69)	2.58 (0.76)	3.30 (0.67)
Peer orientation to school	3.15 (0.76)	3.50 (0.62)	3.13 (0.87)	3.77 (0.70)
Self-concept in science	3.50 (0.76)	3.81 (0.68)	3.49 (0.71)	3.88 (0.71)

Table A7.4. 6th-Extended mean scores on *Aspirations in science* by background characteristic.

Variable and values	*N*	*Mean*	*SD*
Ethnicity	*832*		
Asian	98	3.16	0.85
Black	18	2.82	0.86
Latino	579	3.15	0.90
White	63	3.12	0.97
Other	74	3.05	0.93
Gap (high vs. low)		0.34	
Gender	*830*		
Boy	396	3.14	0.93
Girl	434	3.12	0.88
Gap		-0.02	
Generation of immigration	*823*		
1st	48	3.16	0.79
2nd	513	3.15	0.90
3rd	145	3.04	0.95
4th	117	3.19	0.91
Gap (1st vs. 4th)		0.03	
Home language use	*815*		
Never	98	3.02	0.88
Once in a while	125	3.22	0.96
About half of the time	170	3.04	0.85
All or most of the time	422	3.14	0.90
Gap (Never vs. All)		0.12	
SES	*832*		
Quintile 1 (lowest 20%)	163	3.06	0.85
Quintile 2	170	3.11	0.95
Quintile 3	166	3.20	0.88
Quintile 4	164	3.05	0.95
Quintile 5 (highest 20%)	169	3.22	0.87
Gap (Q1 vs. Q5)		0.16	
School	*832*		
East LA MS	549	3.10	0.92
JMS	93	3.15	0.82
OMS	44	3.17	0.84
SPMS	146	3.21	0.89
Gap (high vs. low)		0.10	
Grand	830	3.13	0.90

A7.2.1.4 Component correlation matrix

Table A7.5 displays the matrix of correlations between the attitudinal variables used in the analysis. Seven of the nine correlations between *Aspirations in science* and the predictor variables are significant, indicating strong bivariate linearity. For example, the largest correlation for the 6th-Extended *Aspirations in science* component is with *Experience of school science* (r = .663). The assumption of bivariate linearity with the dependent variable is evaluated, along with other assumptions necessary for a valid multiple regression, next.

Table A7.5. Bivariate correlations among 6th-Extended variables.

Variable	*SES*	*ESS*	*FA*	*FAS*	*ISN*	*ISP*	*OSS*	*PAS*	*POS*	*SCS*
Socioeconomic status (SES)	-									
Experience of school science (ESS)	.139**	-								
Family ambitions (FA)	-.011	.239**	-							
Family attitudes to science (FAS)	.128**	.540**	.313**	-						
Image of scientists-negative (ISN)	-.182**	-.213**	.057	-.131**	-					
Image of scientists-positive (ISP)	-.045	.503**	.276**	.444**	-.087*	-				
Outside of school science (OSS)	.092**	.448**	.215**	.434**	-.161**	.323**	-			
Peer attitudes to science (PAS)	.250**	.609**	.174**	.366**	-.236**	.351**	.357**	-		
Peer orientation to school (POS)	.214**	.518**	.101**	.324**	-.166**	.260**	.411**	.393**	-	
Self-concept in science (SCS)	.255**	.332**	.111**	.202**	-.133**	.174**	.306**	.286**	.392**	-
Aspirations in science	.048	.663**	.172**	.570**	-.295**	.500**	.479**	.503**	.352**	.208**

Note: * $p < .05$, ** $p < .01$.

A7.2.2 Assessing the data and regression model

The 6th-Extended data was assessed to verify that the data was suitable for a multiple regression analysis (see Appendix 6 for details). Tests included ratio of cases to independent variables, absence of outliers among the variables, variables are normally distributed, independent variables exhibit bivariate linearity with the dependent variable, and absence of multicollinearity. The data met all assumptions. The basic regression model was assessed in Chapter 5 and found to be reliable. Consequently, the results of the regression were assumed to be reliable and are presented next.

A7.2.3 Results of the hierarchical multiple regression of the 6th-Extended data

A hierarchical multiple regression of the 6th-Extended sample data was carried out utilizing the same analytic strategy employed on the 6th and 9th grade East Los Angeles samples (see Chapter 5). In this analysis, however, ethnicity was also included as a background variable. Consequently, the variables in this analysis were entered in this order: (1) ethnicity, (2) other background variables (gender, generation of immigration, home language, and socioeconomic status), (3) nine attitudinal variables theorized to be associated with science aspirations, and (4) school attended. Regression statistics are presented in Table A7.6.

Table A7.6. Hierarchical regression of 6th-Extended predictors on *Aspirations in science*.

Variable and values	Model 1		Model 2		Model 3		Model 4	
Ethnicity								
Asian vs. Latino	0.01		-0.02		0.00		0.00	
Black vs. Latino	-0.04		-0.04		-0.02		-0.03	
White vs. Latino	0.00		-0.04		-0.07	**	-0.07	*
Other vs. Latino	-0.02		-0.06		-0.04		-0.04	
Gender (girl)			0.01		0.03		0.05	
Generation of immigration								
2nd vs. 1st			0.00		0.06		0.06	
3rd vs. 1st			-0.03		0.02		0.02	
Home language use								
Half of time vs. all the time			-0.05		-0.06	*	-0.06	*
Once in a while vs. all the time			0.03		0.03		0.03	
Never vs. all the time			-0.05		-0.03		-0.03	
SES								
Q2 vs. Q1			0.02		0.05		0.05	
Q3 vs. Q1			0.06		0.00		0.01	
Q4 vs. Q1			0.02		-0.04		-0.03	
Q5 vs. Q1			0.15	**	0.01		0.02	
Attitudinal variable								
Experience of school science					0.34	***	0.33	***
Family ambition					-0.04		-0.04	
Family attitudes to science					0.23	***	0.23	***
Image of scientists-negative					-0.14	***	-0.14	***
Image of scientists-positive					0.14	***	0.14	***
Outside of school science					0.16	***	0.17	***
Peer attitudes to science					-0.03		-0.02	
Peer orientation to school					-0.02		-0.02	
Self-concept in science					0.11	***	0.11	***
School								
JMS vs. East LA							0.04	
OMS vs. East LA							0.05	
SPMS vs. East LA							0.00	
R^2	0.00	+	0.02		0.59	***	0.59	***
ΔR^2	0.00	+	0.02		0.57	***	0.00	

Note: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Model 1 shows that student ethnicity, with Latino as the reference category, did not did contribute significantly to the prediction, ΔF (4, 795) = 0.500, p = .735) and accounted for only 0.3% of the variation in *Aspirations in science*. Model 2, with the entry of additional student background characteristics, also did not contribute significantly to the prediction, ΔF (10, 785) = 1.329, p = .210) and accounted for only a further 1.7% of the variation in *Aspirations in science*. Introducing the nine independent variables extracted from the PCA in Model 3 explained an additional 57.0% of variation in *Aspirations in science* and this change in R^2 was highly significant, ΔF (9, 776) = 119.715, $p < .001$. Lastly, the addition of school attended in Model 4 only explained an additional 0.4% of the variation in *Aspirations in science* and this change in R^2 square was not significant, ΔF (8, 768) = 1.003, p = .443.

Once all independent variables were included in Model 4 of the regression analysis, six highly significant ($p < .001$) and two significant ($p < .05$) variables remained in the final model and produced an R^2 of .594 (F (31, 768) = 36.181, $p < .001$) for the prediction of *Aspirations in science*. The six highly significant predictors were all attitudinal variables. The strongest predictor of 6th-Extended aspirations was *Experience of school science* (β = .33), with a large effect size. The next strongest predictor, with moderate effect, was *Family attitudes to science* (β = .23). Following, also with moderate effect size, were *Outside of school science* (β = .17), *Image of scientist-negative* (β = -.14), *Image of scientists-positive* (β = .14), and *Self-concept in science* (β = .11).

The ethnic category White (vs. Latino) was found to be significant (β = -.07, $p < .05$), although with small effect size. The other significant predictor in Model 4 was the category (Use another language at home) Half of the time (vs. all the time) (β = -.06, $p < .05$), also with small effect. The remaining background characteristics and school attended were not significant predictors of *Aspirations in science*. With the aim of gaining deeper insight into the East Los Angeles sample results, each regression model and several of the significant predictors of science aspirations are analysed next.

A7.2.4 Analysis and comparisons of the 6th-Extended regression model

The general pattern of results tracked those of the East Los Angeles models quite closely (see Chapter 5). However, there were several differences in the strength of association each significant predictor had with *Aspirations in science* within the different models. Consequently, this analysis focuses on notable similarities or differences between the results of the 6th-Extended and 6th-East LA regressions.

A7.2.4.1 Model 2 comparisons – Background characteristics

With ethnicity previously entered in Model 1, the entry of additional student background characteristics in Model 2 did not contribute significantly to the prediction of science aspirations for the 6th-Extended sample. Table A7.7 displays regression coefficients at Model 1 for the 6th-East Los Angeles sample[67] and Model 2 for the 6th-Extended sample, with the difference in coefficients calculated as $\Delta\beta = \beta_{Ext} - \beta_{ELA}$. The one notable feature to emerge from this comparison is the significance of socioeconomic status for the 6th-Extended sample; the SES measure did not have a significant linear relation with *Aspirations in science* within the East Los Angles sample. Specifically, students located in Quintile 5 of the SES measure were predicted to have significantly higher science aspirations ($\beta = .148$) than Quintile 1. This result aligns well with the theorized outcome for this variable – higher SES, higher science aspirations – supporting the application of the measure in this study (the reliability and validity of the SES measure is discussed in detail below).

[67] Model 1 of the East LA sample corresponds to Model 2 of the 6th-Extended sample, as the regression analysis of the 6th-East LA sample did not include ethnicity as a predictor variable.

Table A7.7. Comparison of regression coefficients for 6th-East LA (Model 1) and 6th-Extended (Model 2).

Variable and values	6^{th}_{ELA} β	6^{th}_{Ext} β		Δβ
Gender (girl)	.05	.01		-0.04
Generation of immigration				
2nd vs. 1st	.04	.00		-0.04
3rd vs. 1st	-.04	-.03		0.01
4th vs. 1st	.07	-		-
Home language use				
Half of time vs. all the time	-.05	-.05		0.00
Once in a while vs. all the time	-.03	.03		0.06
Never vs. all the time	-.07	-.05		0.02
SES				
Q2 vs. Q1	-.01	.02		0.03
Q3 vs. Q1	.01	.06		0.05
Q4 vs. Q1	.02	.02		0.00
Q5 vs. Q1	-.07	.15	**	0.22

Note: **$p < 0.01$.

A7.2.4.2 Model 3 comparisons – Attitudinal variables

Attitudinal variables were entered into the regression as a block in Model 3 of the 6th-Extended analysis; several statistically significant relations with *Aspirations in science* emerged. As seen in Table A7.8, both the 6th-Extended and 6th-East LA samples shared the same significant components, however, with differing strengths. The two strongest predictors of science aspirations for both samples were *Experience of school science* (β_{Ext} = .343; β_{ELA} = .382) and *Family attitude to science* (β_{Ext} = .232; β_{ELA} = .198). For the 6th-Extended sample, the third strongest predictor of *Aspirations in science* was *Outside of school science* (β_{Ext} = .159), while for the East LA sample it was the fifth of the six significant components (β_{ELA} = .118). The influence of the attitudinal variables on science aspirations is more fully detailed in the analysis of Model 4, presented next.

Table A7.8. Comparison of regression coefficients for 6th-East LA (Model 2) and 6th-Extended (Model 3).

Attitudinal variable	6^{th}_{ELA} β		6^{th}_{Ext} β		Δβ
Experience of school science	.38	***	.34	***	-0.04
Family ambition	.00	+	-.04		-0.04
Family attitudes to science	.20	***	.23	***	0.03
Image of scientists-negative	-.15	***	-.14	***	0.02
Image of scientists-positive	.14	***	.14	***	0.00
Outside of school science	.12	***	.16	***	0.04
Peer attitudes to science	-.05		-.03		0.02
Peer orientation to school	.04		-.02		-0.06
Self-concept in science	.09	*	.11	***	0.01

Note: *$p < 0.05$, ***$p < 0.001$.

A7.2.4.3 Model 4 comparisons – School attended

The inclusion of school attended in Model 4 of the hierarchical regression of the 6th-Extended data did not produce any additional significant predictors of *Aspirations in science*, which was also the case for the 6th-East Los Angeles sample. Four interesting features emerged in the comparison of the final regression models displayed in Table A7.9. First, ethnicity was a significant predictor for the 6th-Extended sample. Specifically, being categorized as Latino predicted significantly higher science aspirations ($\beta = .07$, $p < .05$) than the categorization of White, a small but meaningful effect.

Second, *Experience of school science* (*Eoss*) was the strongest predictor of science aspirations across both samples and models. Given the strength of its effect, it was thought that further analysis of *Eoss* by school attended would provide deeper insight into the variable's influence.[68] Specifically, a one-way ANOVA indicated group differences by school attended (F (3, 829) = 5.78, p =.001) on *Eoss*. Post-hoc Bonferroni procedure showed that SPMS

[68] In order to facilitate comparisons between schools, the six East Los Angeles schools were aggregated.

Table A7.9. Comparison of regression coefficients for 6th-East LA (Model 3) and 6th-Extended (Model 4).

Variable and values	6th ELA β		6th Ext β		Δβ
Ethnicity					
White vs. Latino	-		-0.068	*	-
Black vs. Latino	-		-0.029		-
Asian vs. Latino	-		-0.003		-
Other vs. Latino	-		-0.040		-
Gender (girl)	0.014		0.053		0.04
Generation of immigration					
2nd vs. 1st	0.078		0.059		-0.02
3rd vs. 1st	0.015		0.021		0.01
4th vs. 1st	0.035		-		-
Home language use					
Half of time vs. all the time	-0.060	*	-0.058	*	0.00
Once in a while vs. all the time	-0.015		0.032		0.05
Never vs. all the time	-0.024		-0.033		-0.01
SES					
Q2 vs. Q1	0.007		0.053		0.05
Q3 vs. Q1	0.002		0.007		0.01
Q4 vs. Q1	0.015		-0.034		-0.05
Q5 vs. Q1	-0.095	*	0.019		0.11
Attitudinal variable					
Experience of school science	0.375	***	0.334	***	-0.04
Family ambition	0.000		-0.044		-0.04
Family attitudes to science	0.191	***	0.229	***	0.04
Image of scientists-negative	-0.153	***	-0.137	***	0.02
Image of scientists-positive	0.135	***	0.135	***	0.00
Outside of school science	0.127	***	0.170	***	0.04
Peer attitudes to science	-0.046		-0.023		0.02
Peer orientation to school	0.038		-0.020		-0.06
Self-concept in science	0.102	*	0.114	***	0.01

Note: *$p < 0.05$, ***$p < 0.001$.

(M = 4.07, SD = 0.60) had a significantly higher mean than the aggregate East LA middle school sample (M = 3.79, SD = 0.90) for *Experience of school science*, a small but meaningful effect size, d = .37. This is an unsurprising result: SPHS serves a very affluent community and had much higher quality school science facilities than the East LA schools.

Third, *Outside of school science* was a stronger influence on *Aspirations in science* in the extended sample, in comparison to the East LA sample. While the grand mean of the 6th-Extended sample of 'once a semester', (M = 3.00) indicates little interaction with science outside of school overall, a one-way ANOVA showed differences by school, (F (3, 829) = 6.04, p < .001). SPMS had a higher mean score (M = 3.24, SD = 0.92) than all the schools, although post-hoc Bonferroni procedure showed that SPMS was only significantly different than JMS (M = 2.79, SD = 0.90) on the *Outside of school science* variable, with medium effect size, d = 0.60. With respect to this result, note that the community that JMS serves is majority first-generation immigrants from China (U.S. Census Bureau, 2016); consequently; consequently, it is quite possible that many families at JMS were not fully aware of the type of outside of school science activities referred to in the survey.

Fourth, the inclusion of school attended reduced the predictive significance of SES on 6th-Extended *Aspirations in science*. Note, however, that the variable still acts in the expected direction for Quintile 5 in the 6th-Extended sample ($\beta_{Ext\ Q5}$ = 0.019, p < .05), opposite to that of the East LA sample ($\beta_{ELA\ Q5}$ = - 0.095, p >.05). This result is discussed in detail next.

A7.3 Discussion of the reliability and validity of the SES measure

It was anticipated during the design of this study that any measure of socioeconomic status could be susceptible to a restricted range effect, given the limited socioeconomic diversity of the main study's location (East Los Angeles). One effect of the restricted range would be to reduce the sensitivity of the SES measure, limiting its ability to differentiate between students and account for variance in the regression analysis of the *Aspirations in science* measure – precisely the outcome of the main study's regression analysis. In order to establish whether the restriction of range in the SES measure accounted for its low reliability when applied to

the East LA samples, the SES measure was evaluated through four comparisons between the 6th-East LA and the 6th-Extended samples.

First, note that there were clear differences between the CatPCA solutions used to generate the SES measure. Table A7.10 displays the loadings on the first component of the CatPCA solution; it shows greater loadings for all 6th-Extended variables, compared to the 6th-East LA sample. Further, the solution for the 6th-Extended sample accounted for 47.56% of the variance in the SES measure with a Cronbach's alpha of $\alpha = .724$; the 6th-East LA sample accounted for 33.52% of the variance in the SES measure with a Cronbach's alpha of $\alpha = .504$. This is a difference in internal consistency reliability of $\Delta\alpha = .724 - .504 = .220$, a percent difference of 36%.

Table A7.10. CatPCA component loading for the 6th grade SES measure.

SES input variable	6th-East LA loadings	6th-Extended loadings
Home intellectual resources	.441	.661
Home ownership	.467	.570
Home possessions	.709	.763
Parent highest educational level	.564	.727
Parent highest job level	.665	.711
Cronbach's alpha	.504	.724

Second, as seen in Table A7.11, every CatPCA input variable had higher correlations with the 6th-Extended SES measure, in comparison to the 6th-East LA sample. The smaller correlations observed for the 6th-East LA sample are the result of the restricted range of scores on the input variables. This attenuation in range within the East Los Angeles sample can be observed, for example, by examining the variable with the greatest range (1 - 9) and largest correlation with the SES measure for both samples: *Home possessions* ($r_{6th\text{-}ELA}$= .647; $r_{6th\text{-}Extended}$ = .716). Figure A7.4 displays the distribution of scores on this variable, by percentage, for both samples. Inspection of the 6th-East LA score distribution shows that less than 15% of the scores extend into the upper third of the range (6-9), compared to about one third (30%) of the 6th-Extended sample.

Similarly, Figure A7.5 displays the distribution of scores on the variable with the second largest range (1 - 5), *Parent highest job level*. Again, the 6th-East LA sample had less than 15% of its scores on the highest two of five ordinal categories. Comparable distribution patterns were observed for the other three input variables utilized in the SES measure (*Home intellectual resources*, *Parent highest education level*, and *Home ownership*).

Table A7.11. Comparison of SES input variable correlations with *SES* by sample.

Variable	*SES* 6th-East LA	*SES* 6th-Extended
Home intellectual resources	.364**	.632**
Home ownership	.502**	.554**
Home possessions	.647**	.716**
Parent highest education level	.495**	.665**
Parent highest job level	.352**	.505**

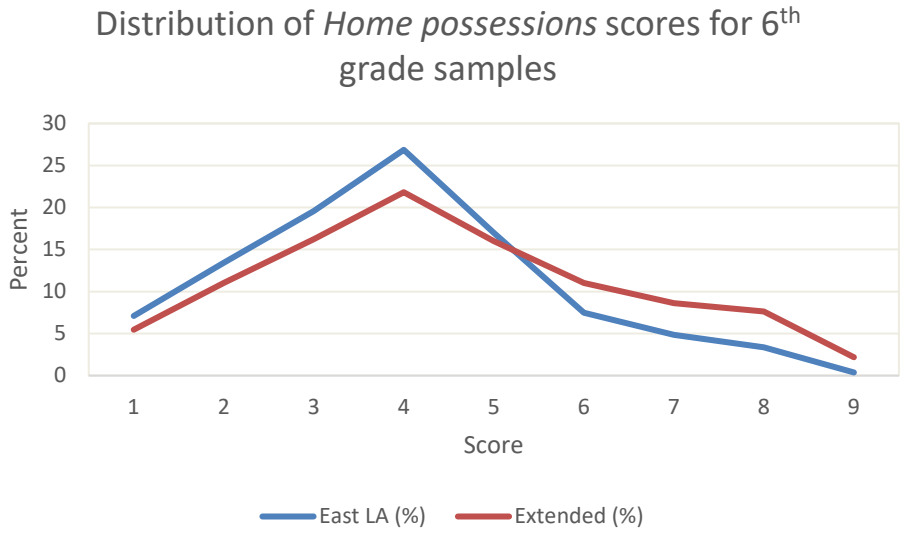


Figure A7.4. Percent distribution of *Home possessions* scores for 6th grade samples.

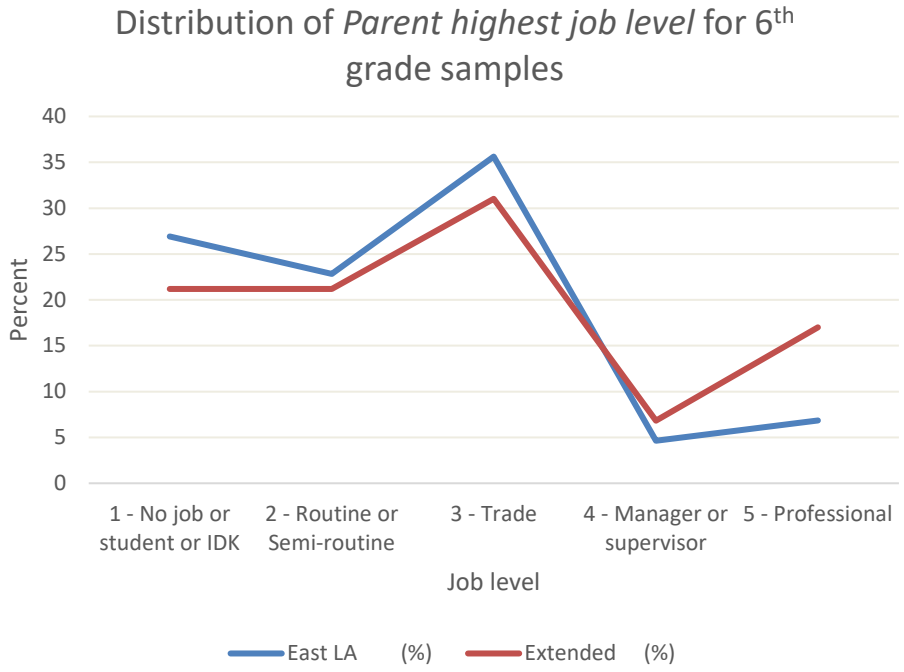


Figure A7.5. Distribution of *Parent highest job level* for 6th grade samples.

The difference in each samples' general range across the SES measure's input variables is encapsulated by the bivariate Spearman correlations among the variables, shown in Table A7.12. Note that all pairs of 6th-Extended variables are significantly correlated (15 of 15). By comparison, just two-thirds (10 of 15) of the 6th-East Los Angeles sample variables were significantly correlated (see Table A5.9).

Third, there were notable differences between the two SES measures' linear correlations with the attitudinal variables used in the regression analysis. As seen in Table A7.13, there is an increase in the number of significant correlations, going from two for the 6th-East LA sample to seven for the 6th-Extended extended sample. The table also shows an increase in the strength of association with the 6th-Extended SES measure for seven of the nine attitudinal variables, compared to the 6th-East LA measure.

Table A7.12. Spearman correlations among 6th-Extended SES variables.

Variable	*SES*	*HIR*	*HO*	*HP*	*PHEL*
SES	-				
Home intellectual resources	.632**	-			
Home ownership	.554**	.221**	-		
Home possessions	.716**	.352**	.392**	-	
Parent highest education level	.665**	.285**	.245**	.353**	-
Parent highest job level	.505**	.279**	.181**	.296**	.322**

Note: * $p < .05$, ** $p < .01$.

Table A7.13. Comparison of *SES* correlations with attitudinal variables, by sample.

Attitudinal variable	*SES* 6th-East LA	*SES* 6th-Extended
Aspirations in science	-.057	.048
Experience of school science	.000	.139**
Family ambitions	.081	-.011
Family attitudes to science	.068	.128**
Image of scientists-negative	-.023	-.182**
Image of scientists-positive	-.057	-.045
Outside of school science	.080	.092**
Peer attitudes to science	.139**	.250**
Peer orientation to school	.055	.214**
Self-concept in science	.091*	.255**

Note: * $p < .05$, ** $p < .01$.

Lastly, additional insight into the attenuation of range within the East Los Angeles samples is gained by revisiting Figure A7.2. Recall that Figure A7.2 displays the distribution of socioeconomic quintiles, by school, in the 6th-Extended and 6th-East LA samples. As seen in the figure, the East Los Angles schools are not proportionately represented throughout the five quintiles; more than 95% of East Los Angeles students are restricted to Quintiles 1 through 4.

In summary, the socioeconomic measure was shown to be reliable when applied to data with greater socioeconomic variation (i.e., the 6th-Extended sample), as measured by Cronbach's alpha. As discussed in this section, the reduced sensitivity of the measure applied to the East LA samples was understood to be the effect of the reduced range of the variables that comprise the SES measure, relative to the 6th-Extended sample. Taken together, the above analysis demonstrates the overall reliability and validity of the socioeconomic measure in predicting science aspirations.

APPENDIX 8 MATERIAL FROM TEACHER INTERVIEWS

A8.1 CUREC 1A for Teacher Interviews

CENTRAL UNIVERSITY RESEARCH ETHICS COMMITTEE (CUREC)

Form CUREC 1A Checklist for the Social Sciences and Humanities

UNIVERSITY OF OXFORD

The University of Oxford places a high value on the knowledge, expertise, and integrity of its members and their ability to conduct research to high standards of scholarship and ethics. The research ethics clearance procedures have been established to ensure that the University is meeting its obligations as a responsible institution.

They start from the presumption that all members of the University will take their responsibilities and obligations seriously and will ensure that their research on human subjects is conducted according to the established principles and good practice in their fields and in accordance, where appropriate, with legal requirements. Since the requirements of research ethics review will vary from field to field and from project to project, the University accepts that different guidelines and procedures will be appropriate.

- Please check "Where and how to apply for ethical review" and the CUREC flowchart first to see if you need ethics approval.
- Please complete this form using a word processor and email it, together with your supporting documents, to your Departmental Research Ethics Committee (DREC) (**if applicable**). If you don't have a DREC please email this form to ethics@socsci.ox.ac.uk using your official **ox.ac.uk email** address. **Only emailed applications will be accepted.**

WHAT THIS CHECKLIST IS DESIGNED FOR

This **CUREC 1A checklist** is designed largely for research that falls within the Divisions of Social Sciences and Humanities where ethical issues are relatively few and straightforward. Interviews, field work and oral history are also included in the CUREC process.

The **full CUREC 2 application** is only required where certain project characteristics (e.g. type of participants, or procedures) result in a more complex set of ethical issues. It is expected that only in a limited number of cases will it be necessary for researchers to complete a CUREC 2 application. The checklist below will direct you to a CUREC 2 application if needed.

WHAT THIS CHECKLIST WILL NOT ASSESS

This checklist does not cover research governance, satisfactory methodology, or compliance with the requirements of publishers when administering their tests or questionnaires. As principal researcher, it is your responsibility to ensure that requirements in these areas are met.

CUREC does not review studies classed as **audit** (see Glossary and Decision Flowchart for CUREC on our website).

If your study involves **NHS patients, NHS staff / data / facilities, or human tissue**, please check the Decision Flowchart for NHS approval and contact the Clinical Trials and Research Governance (CTRG) team in the first instance.

Further information on the University's research ethics procedures is available from the CUREC website.

SECTION A: Filter for CUREC2 application

This section determines whether your study raises more complex issues which require the completion of a full application for ethical review, known as the CUREC 2 application.

(Please mark 'X' in the Yes/No column as appropriate to indicate your response.)

1.	Are research participants classed as **people whose ability to give free and informed consent is in question**? (This may include those under 18 (though see "competent youths"), prisoners, or adults "at risk".) Your attention is drawn to the University's **Safeguarding Code of Practice** and its implications for researchers involving children or adults at risk, including the need for the work to be risk assessed and for researchers to undertake related training. (**Note**: If any of your participants are aged 16 or under, please answer 'Yes' here **and** also answer question 5 below.)	Yes	No X
2.	By taking part in the research, will participants be at serious risk of criminal prosecution (e.g. by providing information on drug abuse or child abuse)?	Yes	No X
3.	Does the research involve the **deception** of participants?	Yes	No X
4.	Does your research raise issues relevant to the **Counter-Terrorism and Security Act (the Prevent duty)**, which seeks to prevent people from being drawn into terrorism? Please see advice on this on our **Best Practice Guidance web page**.	Yes	No X

If you have answered 'No' to all of the questions above please go to **Section B**. If you have answered 'Yes' to any question above continue to question 5 below.

5.	Is your project covered by a CUREC approved procedure (formerly known as "CUREC Protocols")?	Yes	No
	If yes, please give research procedure number(s):		

If you answered '**Yes**' to **ANY** of questions **1-4**, **and** answered '**No**' to question **5**, **please stop completing this checklist and do not submit it for ethical review**. Instead, please complete the CUREC 2 application form from the CUREC website. Then submit the CUREC 2 form for ethical review.
If you answered 'Yes' to ANY of questions 1-3, **and** answered 'Yes' to question 5, please go on to **Section B**.

SECTION B: Contact details and project description (NB: must be typed not handwritten)

Contact details:

1.	**Principal researcher/**supervisor (title and name) (if student research):	Doctor Judith Hillier Professor Steve Strand
2.	Name of student (if student research):	Leif Andersen
3.	Degree programme, e.g. DPhil, BA, MPhil, BSc, MSc (if student research):	DPhil
4.	Department or Institute name:	Education
5.	Address for correspondence (if different from above):	
6.	University e-mail (**not** private email) and telephone:	leif.andersen@pmb.ox.ac.uk
7.	Name and status of others taking part in the project, e.g. third year undergraduate; postdoctoral research assistant:	N/A

SECTION B continued	
Project description:	
8. Title of research project:	Aspirations and the Underrepresentation of Latinos in the Physical Sciences in Los Angeles, California, USA
9. List of location(s) where project will be conducted:	Middle and High Schools within the Los Angeles Unified School District.
10. If your research involves overseas travel or fieldwork, by the time the research starts, will you have completed and returned a travel risk assessment form? (This has to be approved by your department before you travel. If you are travelling overseas, you are strongly advised to take out University travel insurance.)	Yes X No N/A
11. Anticipated duration of research project overall:	3 months
12. Anticipated start and end dates of the research project involving human participants:	From: (03/26/18) To: (06/26/18) Please note that you will need ethics approval **before** you start your research. CUREC1As may take up to 30 days to process.
13. External organisation funding the research (if applicable): N/A.	
14. Title and very brief and simple lay description of **research** (about 150 words), plus description (about 200 words) of the nature of participants.	
a) Title, brief description of research (150 words) in lay language. When describing the research, please include your methodology, how you are applying professional guidelines, and the use to which results/data will be put. **Please also declare any conflicts of interest here.**	

Title:

Aspirations and the Underrepresentation of Latinos in the Physical Sciences in Los Angeles, California, USA.

Overview:

This research is designed to be the final component of a larger systematic investigation of the aspirations of US Latino youth towards education and careers in the physical sciences that previously has been granted approval by CUREC. The overall study, conducted in East Los Angles, aims to fill a gap in knowledge in the scholarly literature addressing a critical aspect in the pipeline from middle school to high school and beyond in aspirations to study physical science. Preliminary findings from the study indicate that family relationship and experience of school science are of significance in predicting aspirations in science for this group of students. The key questions of the study are:

1. What are the aspirations of 6th Grade Latino students to study the physical sciences?
2. What are the aspirations of 9th Grade Latino students to study the physical sciences?
3. Are there differences in science aspirations between the above two (cross-sectional) samples?
4. Which factors predict the strength of aspirations to study science in the East Los Angeles sample? In particular, what is the role of student attitude to school and science self-concept, parental attitudes to science, peer attitudes to science, images of scientists and engagement in science related activities outside of school?
5. What are the associations between science aspirations and age, gender, socio-economic status and other student characteristics?

Methods:

This component of the study is designed to conduct semi-structured interviews with each of the teachers (six middle school and six high school) that were involved in the main study. The interviews will be audio recorded. Using semi-structured interview format is appropriate in that the aim of the interviews is to explore teachers' reflections on the initial findings of the study involving their students. It is thought that information obtained from the interviews might provide additional insight into answering the research questions addressed by this study, particularly RQ 4.

Conflicts of interest:

No conflicts of interest are anticipated in this study.

SECTION B continued

b) Description of participants and **obtaining informed consent** (200 words). When describing participants, please include

- criteria for inclusion/exclusion
- method of recruitment
- processes for consent to participate

Please ensure you attach as separate documents (if applicable, in English translation):

- your recruitment and advertisement material e.g. a poster or brief invitation letter/ email
- information for participants to read (or hear) before they agree to take part e.g. written information sheets or (only if applicable) oral information scripts.
- a document to record informed consent. Templates for written consent forms and/or oral information scripts (in case of an oral consent process) are available from the CUREC website
- a guide to interview questions (this may be a list of questions to be asked, or a preliminary scope of questions), or a sample of other instruments (such as a sample questionnaire)
- (if relevant) debriefing document after participants have taken part

Information letters and consent forms will be sent to principals and teachers of the schools that previously participated in the earlier stages of this study (see appendices A and B). Informed consent will be obtained before an interview takes place. To ensure protection of participants, this study adheres to CUREC Best Practice Guidenace 11 – Anonymisation and Identifiers. It will be emphasized that participation in this study is voluntary and can be withdrawn at any time without consequence. A list of questions to be asked is attached as Appendix C.

Relevant documents are attached as appendices.

15. What are the ethical issues connected with your research and what steps have you taken to address them? Please do not answer 'none'. The committee needs to see evidence that you have identified potential ethical issues with respect to your research and have taken steps to address them. These issues could relate to:

- your own physical and psychological safety as a researcher (please see the University's and Social Science Division's Safety in Fieldwork guidance
- participant burdens and/or risks, and
- data protection/ confidentiality.

For more guidance on ethical issues, please see
http://researchsupport.admin.ox.ac.uk/governance/ethics/resources

It is anticipated that no harm, burden, risk, or possible injury to either participants or researcher will result from this study. Personal or sensitive data will be captured, transferred, and stored securely per BPG 09 – Management of Data Collected for Research Purposes. In particular, no reference to individuals will be made within the final report, and thus anonymity will be upheld. All consent forms and individual paper-records will be kept in a locked filing cabinet. Anonymized data keys will be stored separately from data sets. The anonymized data in Microsoft Word format will be securely stored by the researcher on password encrypted storage media. The researcher's supervisors will have copies of this data, also password encrypted. Electronic data will be stored indefinitely.

Section B continued

16. Will you obtain informed consent according to CUREC guidelines and good practice in your discipline before participation?	Yes X	No
If you have marked '**No**', please give a brief explanation and justification for this decision here:		
17. Will your research involve discussing sensitive issues? This could be information relating to race or ethnic origin, political opinions, religious beliefs, physical/mental health, trade union membership, sexual life or criminal activities.	Yes	No X
If you have marked '**Yes**', please make sure that you have included some **supporting information** (as directed in question 14 of this section) showing the range of questions covering these issues.		
18. Will you ensure that **personal data** collected directly from participants or via **a third party** is held and processed in accordance with the provisions of the Data Protection Act?	Yes X	No
19. How will you ensure that any personal and/or sensitive data are captured, transferred and stored securely? In particular if data are to be captured electronically, please consult with the University's research data team (**researchdata@ox.ac.uk**) and your local IT department and, with respect to University IT security policies, please comment on how you will capture such data in the first instance, how you will transfer them over networks or via portable media and how, where and how long data will be stored. For more information please see the University's web pages on research data management.		

This study will ensure that personal and/or sensitive data are captured and stored securely per BPG 09 – Management of Data Collected for Research Purposes. Specifically, all consent forms and individual paper-records will be kept in a locked filing cabinet. Anonymized data keys will be stored separately from data sets. The anonymized data in Microsoft Word format will be securely stored by the researcher on password encrypted storage media. The researcher's supervisors will have copies of this data, also password encrypted. Electronic data will be stored indefinitely.

SECTION C: Methods and procedures to be used

Method used: Please ensure you have addressed any potential ethical issues related to these methods in Section 14 and in your Participant Information Sheet	**Please mark 'X'**
1. Analysis of existing records	
2. Snowball sampling (recruiting through contacts of existing participants)	
3. Use of casual or local workers e.g. interpreters	
4. Participant observation	
5. Covert observation	
6. Observation of specific organisational practices	
7. Participant completes questionnaire in hard copy	
8. Participant completes online questionnaire or other online task	
9. Using social media	
10. Participant performs paper and pencil task	
11. Participant performs verbal or aural task (e.g. for linguistic study)	
12. Focus group	
13. Interview	X
14. Audio recording of participant (you will generally need specific consent from participants for this)	X
15. Video recording of participant (you will generally need specific consent from participants for this)	
16. Photography of participant (you will generally need specific consent from participants for this)	
17. Others (please specify):	

SECTION D: Professional guidelines and training

In this section, please mark 'X' against at least one of the following professional guidelines you aim to adhere to. You should use the principles listed in your chosen guideline(s) in conducting your own research. **Note**: this is not an exhaustive list.		**Please mark 'X'**
Research specialism/ methodology	**Association and guidance document**	
Anthropology	Association of Social Anthropologists of the UK and Commonwealth	
Criminology	British Society of Criminology: Code of Ethics for Researchers in the Field of Criminology	
Education	British Educational Research Association Ethical Guidelines for Educational Research	X
Geography	Association of American Geographers Statement on Professional Ethics Royal Geographical Society: Research Ethics and Code of Practice	
History	Oral History Society of the UK Ethical Guidelines	
Internet-based Research	British Psychological Society: Conducting Research on the Internet Association of Internet Researchers Ethics Guide Also see our Best Practice Guidance on internet-based research	
Law (Socio-Legal)	Socio-Legal Studies Association: Statement of Principles of Ethical Research	
Management	Academy of Management's Professional Code of Ethics	
Political Science	American Political Science Association (APSA) Guide to Professional Ethics in Political Science	
Politics	Political Studies Association. Guidelines for Good Professional Conduct	
Psychology	British Psychological Society Code of Ethics and Conduct British Psychological Society: Conducting Research on the Internet Also see "Internet-based Research" guidance above	
Social Research	Social Research Association: Ethical Guidelines	
Sociology	The British Sociological Association: Statement of Ethical Practice	
Visual Research	ESRC National Centre for Research Methods Review Paper: Visual Ethics: Ethical Issues in Visual Research	
Other professional guidelines. Please specify the other guidelines used here:		

Please indicate what training in research ethics the researchers involved with this study have received, e.g. the title of the course and date completed (online training available at http://researchsupport.admin.ox.ac.uk/support/training/ethics).

If no formal training has been undertaken, please indicate any discussions of research methodology between researchers and supervisors here.

No formal training in semi-structured interviews by the researcher has been done. Research methods have been discussed with the researcher's supervisors. Both a pilot study and a main study were conducted between December 2015 and June 2016; no ethical issues with the study emerged.

SECTION E: Signatures

- 'Electronic signatures' sent as email confirmations from a University of Oxford email address can be accepted. Separate emails should come from each of the relevant signatories as outlined below, indicating acceptance of the relevant responsibilities.
- If you have obtained handwritten (wet-ink) signatures, please scan them and the rest of the checklist pages to create a single PDF document and email through.

Please ensure this checklist is signed by:

For staff research:	For student research:
1. Principal researcher	1. Principal researcher (project supervisor)
2. Head of Department (or nominee)	2. Head of Department (or nominee)
	3. Student researcher

1. Principal researcher signature/supervisor signature (if student research)

I understand my responsibilities as principal researcher as outlined in the CUREC glossary and guidance on the CUREC website.

I declare that the answers above accurately describe the research as presently designed, and that a new checklist will be submitted should the research design change in a way which would alter any of the above responses so as to require completion of CUREC 2 (involving full scrutiny by an IDREC). I will inform the relevant IDREC if I cease to be the principal researcher on this project and supply the name and contact details of my successor if appropriate.

Signature:

Print name (block capitals): **Date**:

2. Departmental endorsement signature

I have read the research project application named above. On the basis of the information available to me, I:

(i) consider the principal researcher to be aware of her/his ethical responsibilities in regard to this research;
(ii) consider that any ethical issues raised have been satisfactorily resolved or are covered by relevant professional guidelines and/or CUREC approved procedures, and that it is appropriate for the research to proceed (noting the principal researcher's obligation to report should the design of the research change in a way which would alter any of the above responses so as to require completion of a CUREC 2 full application);
(iii) am satisfied that: the proposed project design and scientific methodology is sound; the project has been/will be subject to appropriate peer review; and is likely to contribute to existing knowledge and/or to the education and training of the researcher(s) and that it is in the public interest.

Signed by Head of Department or nominee *(example nominees for student research include the Director of Graduate Studies/ Director of Undergraduate Studies)*:

Signature: .....

Print name (block capitals): ..... **Date**: .....

3. Student signature (if student research)

I understand the questions and answers that have been entered above describing the research, and I will ensure that my practice in this research complies with these answers, subject to any modifications made by the principal researcher properly authorised by the CUREC system.

Signed by student: Leif Andersen

Print name (block capitals): LEIF ANDERSEN **Date**: March 2, 2018

SECTION F: SUBMITTING THE COMPLETED CHECKLIST	Please mark 'X'
1. Check you have completed all sections (A-E)	X
2. Ensure your application is signed by you, your supervisor (if student) and department	
3. **Please attach all supporting documents (see section B, question 14b for details).** If the appropriate supporting documentation is not included with your application, you will then be asked to provide this separately. **This may well delay the ethical review process, and thus the start of your research.**	X
4. Ensure you have declared conflicts of interest (if any) in Section B, question 14a.	X
5. If your department has a Departmental Research Ethics Committee (DREC), submit this checklist and supporting information to the appropriate departmental officer.	
6. If your department does not have a DREC, submit the checklist and supporting information to the SSH IDREC (email ethics@socsci.ox.ac.uk).	
7. Applications must be sent by email from your official ox.ac.uk email account. Please do not send applications by post.	X

A8.2 Teacher Consent Form

UNIVERSITY OF OXFORD
DEPARTMENT OF EDUCATION

15 Norham Gardens, Oxford OX2 6PY
Tel: +44(0)1865 274024 Fax: +44(0)1865 274027
general.enquiries@education.ox.ac.uk www.education.ox.ac.uk

Director Professor Jo-Anne Baird



Aspirations in the Physical Sciences of Young People in Los Angeles – Teacher Interview

Researcher: Leif Andersen-Monserratte

Teacher Declaration of Consent:

I hereby confirm that (please tick boxes):

- ☐ I have read the participant information sheet and have had the opportunity to ask questions about the study and receive satisfactory answers to questions.
- ☐ I understand that the participation is voluntary and that I am free to withdraw from the study at any time by simply advising the researcher, and any data already recorded will be discarded.
- ☐ I understand that this project has been reviewed by, and received ethics clearance through, the University of Oxford Central University Research Ethics Committee.
- ☐ I understand that all personal data will be treated in total confidence, kept securely in a password-controlled server, and what will happen to the data at the end of the project.
- ☐ I understand that I will have the opportunity to review and comment on any analysis before publication. I understand how to raise a concern and make a complaint, and agree to participate in this study.
- ☐ I understand that there will be an audio recording of the interview and I agree to be audio recorded.

Your Name: _____

Your Signature: _____ Date:_____

A8.3 Teacher Interview questions

The following is the list of teacher interview questions for the semi-structured interview phase of the study.

Initial findings

Analysis of the ASPIRES survey indicate that several attitudes appear to be significant in shaping students' aspirations in science. I'm going to list three of the most relevant and would like you to tell why you think student aspirations in science trend this way.

- Why Family attitudes to science?
- Why Self-concept in science?
- Why Experience of school science?
- Are any of these factors related to aspirations we discussed a surprise to you?

There were other factors theorized to be related to aspirations.

- Background variables such as generation of immigration, SES, and home language were not found to be influential to aspirations. Why do you think this might be so?
- Is there a factor other than those we just discussed that you might expect to be relevant or influential? Why?

Implications

Given the findings we have just discussed, could you tell me

- What you think this means for your students' aspirations in science?
- What might this mean to your teaching of science?
- What implications might this have for your science curriculum as it is currently constructed?

Interventions

There is ongoing interest in stimulating and maintaining these students' interest and participation in the sciences. This interest typically manifests as some type of intervention.

- Are you aware of such intervention programs? If so, what are your thoughts on the effectiveness of the program?
- Have you participated in such an intervention program? If so, what are your thoughts on the effectiveness of the program?
- To what extent do you think that such intervention programs account for the findings of this study?
- Do you think it would be possible to incorporate findings from this study into an intervention program? Why or why not?

Future studies

- Given your experience participating in this study, is there any insight you would like to offer regarding student aspirations in science?

A8.4 Initial coding of teacher interview data

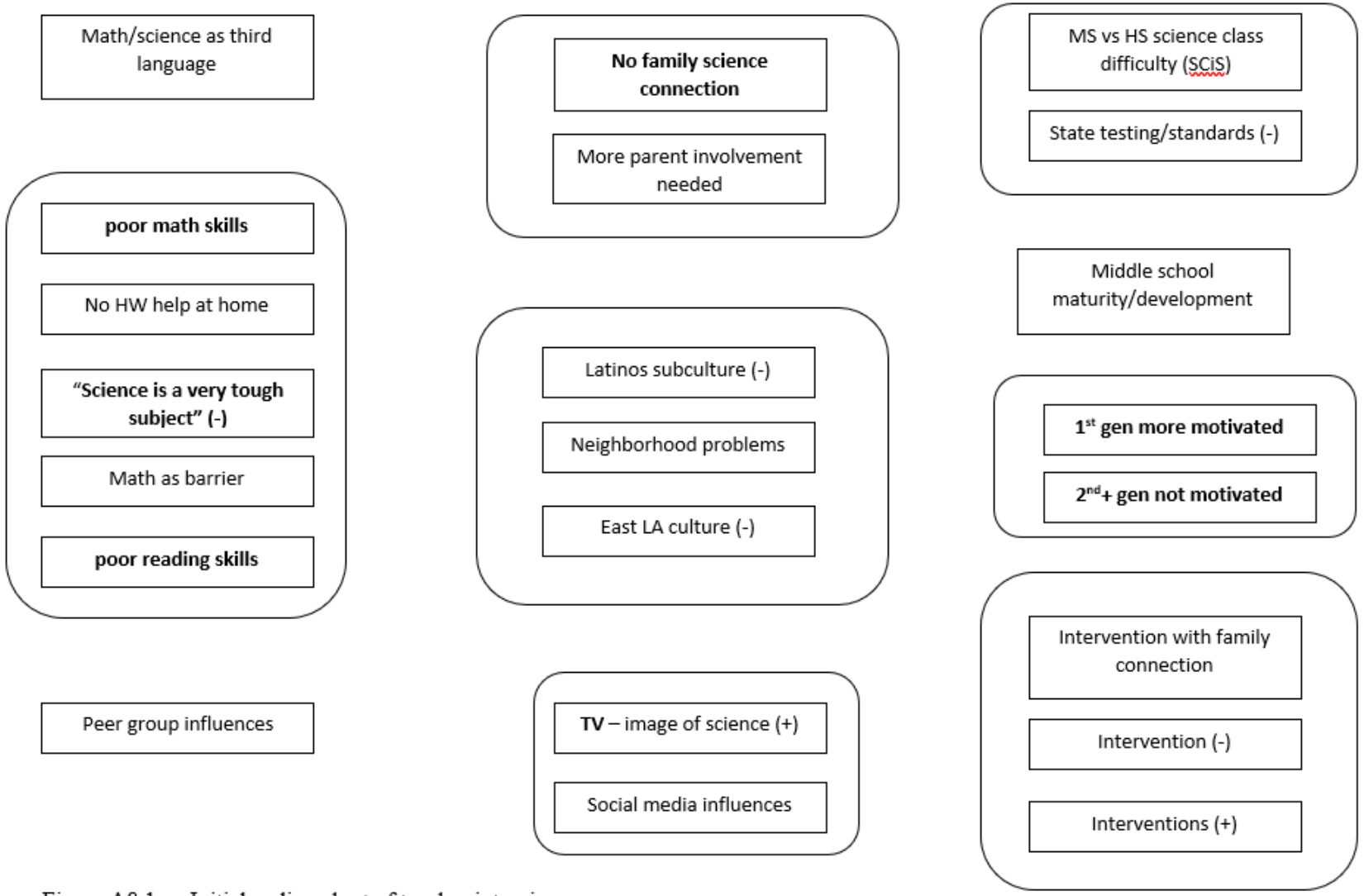


Figure A8.1a. Initial coding chart of teacher interviews.

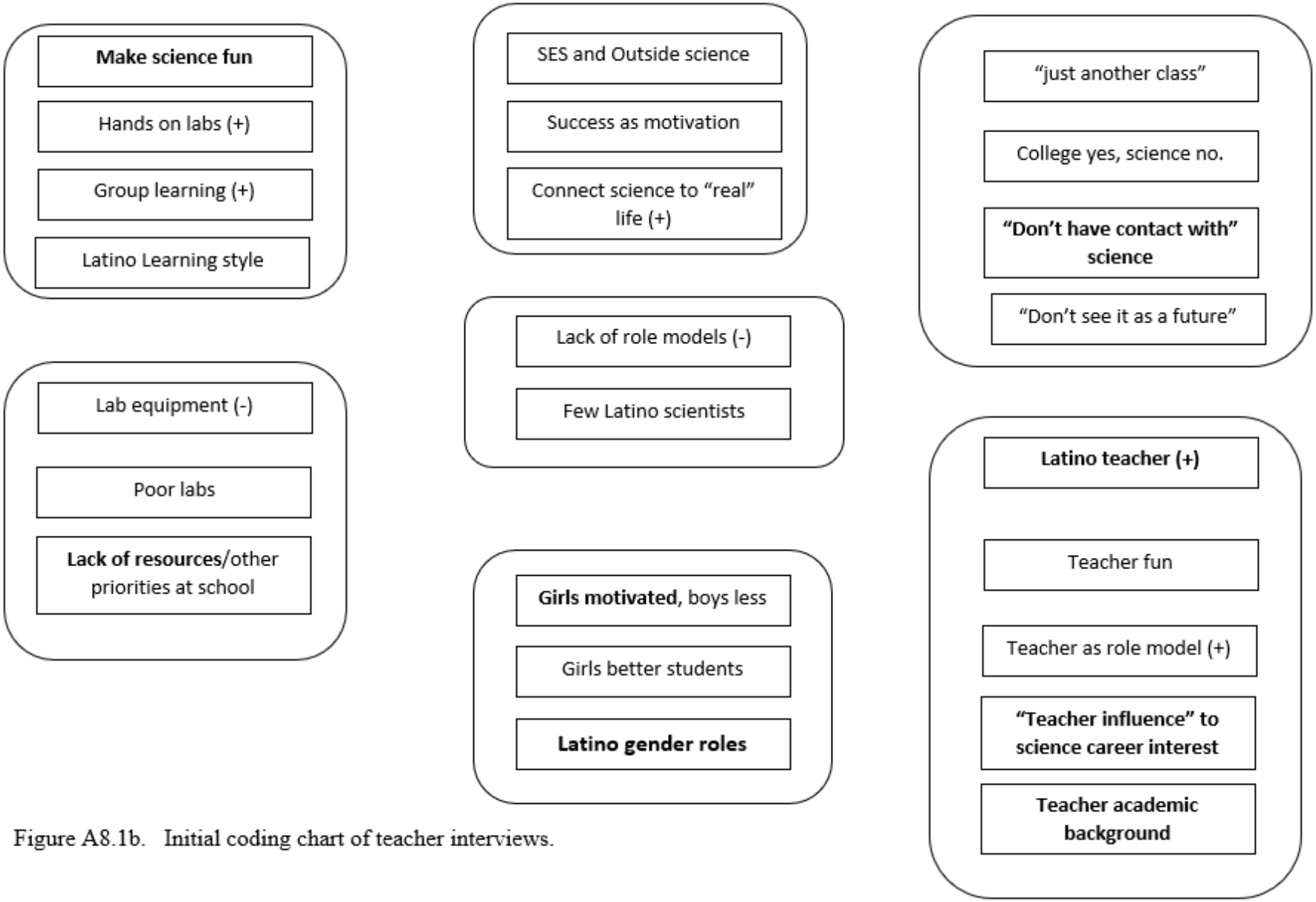


Figure A8.1b. Initial coding chart of teacher interviews.

A8.5 Sample teacher interview data

Leif Andersen:
[00:00:00] All right. So, you were saying about the rocks.

AM:
[00:00:05] Rocks. I emphasize how they make society and life and better. And also, I wanted them to explore rocks as not something that they just find out there and kick around, but that is something that is very useful and beautiful. And makes society and much better. That's that was my whole emphasis on the curriculum.

LA:
[00:00:28] What is your background?

AM:
[00:00:30] I have an engineering background.

LA:
[00:00:32] You are not doing an engineering curriculum (like Mr. Dean) even though you have an engineering background.

AM:
[00:00:39] I have a degree in civil engineering.

LA:
[00:00:41] Do you think that makes a difference

AM:
[00:00:43] Yes in a certain way it does. Because also, I have the ability to explain to them how rocks and minerals form in terms of numbers. How molecules work with other molecules to make a rock from a mineral… And they saw that and they liked that. And then I would relate to them the difference between a mineral and a rock. How a mineral has to be pure. Have certain qualities - can't be organic - How that creates something as complex as rock. And I will use granite, and break apart granite into the components that it's made out of. Parts that are a lot of silica, lot of basalt...things like that. And they like it. We broke apart a lot of rocks.

LA:
[00:01:35] Okay. Let me ask you a couple of questions specific to your class. Let me remind you we were looking at how many of these students, of your students were interested in pursuing a career in the future. And it turned out after we analyzed the results of the survey, that the most important of the things that was linked to aspirations was their own family's' attitudes towards science. Can you give some insight into why that might be the case?

AM:
[00:02:15] Because also a lot of the time they science as a career that is going to bring them out of the poverty that they live in. And they equate things like doctors with science. They equate engineers with science. A person in the scientific field is not someone who is going to be impoverished. And I think that is very important, because the parents see that.

LA:
[00:02:46] There were three things that were important to aspirations. The next one was self-concept in science, which was quite low for your students…

AM:
[00:03:05] I think it's the connection to math. Because of me... I have been explaining my experience. So, if they are going to connect to a science career, they're going to have master the hardest part from their perception, which is math.

LA:
[00:03:22]
Generally speaking their math isn't that strong as...

AM
[00:03:27] No.

LA:
[00:03:28] Any insight into that?

AM:
[00:03:31] Because the attitudes of math, because math is such an abstract concept to them. It's learning a new language when they are already trying to learn a new language of English, apart from learning the math. It complicates it quite a bit for them.

LA
[00:03:52] That makes sense.

AM:
[00:03:53] If you've already mastered a language, let's say the English language. Somebody that is not from this community, that's not practicing two or three languages. We've already mastered that one language. Then we move to the second language of math, because math is a language. Then they are not only trying to master that other language with...as well as perfecting the English language. These guys are trying to master three or four at the same time. And that language of math becomes third or fourth in the value system. That's why it becomes more complicated.

LA:
[00:04:26] So you think that's the main reason why because they're associating science with math and they don't have their own ideas about math at this point. And that's really interesting. The third and the last most important concept was the experience of school science. An

interesting thing: your students had the highest experience of school science of all the kids of all the middle schools. Now, even though they're experience of school science was very high at the same time most of your students didn't really have high aspirations for a career in science. And so, there's this dichotomy this where they really like the school science, but they don't really see themselves doing science in the future. Can you give me some insight on that?

AM:
[00:05:05] The same reason. Because when we did.... They love the fun aspect of activities, of breaking things up, putting things together. But when it came down to the analytical part and we had to use math again for analyzing whatever it is we were experimenting on... that's where they realize, “Oh, that I have to master this math part to actually be able to do this out in the real world”. And that was what I brought up using my experience.

LA
[00:05:35] So you're saying that the experiences of school science, that the enjoyment of it, even though they do enjoy... That they that they don't see themselves because of other, outside matters...

AM:
[00:05:47] Exactly.

LA;
[00:05:51] Generally speaking children at this age, boys tend to like science more than girls. Your classes, the girls liked it more than boys. If you have any insight...

AM:
[00:06:06] Because I would equate it with things like… at home in this culture. The girls are the ones that are learning to cook a steak. And the cleaning aspect that uses a lot of chemicals and things like that. And I would incorporate that into the science curriculum of household aspects of science. So, the girls will realize “Well, I'm already doing this. I might have to mix these chemicals to clean that and I have to mix these ingredients to make that work. I know I have to use heat to transform things in the kitchen.” So, they would start identifying with a science component.

LA:
[00:06:39] Okay. All right.

AM:
[00:06:41] And boys don't necessarily do that in our culture. They're not the one cleaning. Which is bad, but that's just the way it is.

LA:
[00:06:53] There's a couple other things. One was socioeconomic status. Even within the community of East LA there’s differences. Generally speaking, the higher your social economic status, the more likely you are to believe that you can do some science. Your

children's socioeconomic status didn't seem to matter. In other words, that the lowest on the scale and the highest on the scale aspire – statistically - the same. Any insight on that?

AM:
[00:07:21] Because we were transitioning to a STEAM magnet school - that's STEM with art - and I think we were kind of emphasizing that part… of the importance of the science components, throughout the general education. And I think the students were starting to gear towards that because we were emphasizing it in almost every class. The English class. The language class will help me with the writing of the science experiments, with some reasons, the conclusions…. and they helped me do that as well. So, it was a full group thing.

LA:
[00:08:07] Okay two other things. Generation of immigration. It turns out that usually first-generation ones that come from let's say Mexico tend to do be more oriented towards doing science and school in general. Your students didn't have that. It didn't matter what generation of immigration they came from. Any insight on that?

AM:
[00:08:27] Again because of the emphasis that we are placing on the importance of science in the whole curriculum through the language classes. Every class.

LA:
[00:08:36] Which brings me to home language used. Some indicators show that if you use mainly a foreign language, like Spanish, you're not going to be as academically motivated as someone who uses less at home. That's the general literature. Your students weren't didn't follow that pattern. It didn't matter what language they spoke at all.

AM:
[00:08:57] They were immersed in the science components throughout the entire school curriculum. And also, I made them go home and think about the science aspects of living, of your house. So, the things you do at home, from basic cooking to basically anything. Turning on the TV. I try to bring all that into the classroom to show them how things work. So that they know that everything is based on science, technology - everything.

LA:
[00:09:21] Okay, excellent and just a couple more here. If a new group of students were to walk in the door today - new semester. What would you think they're STEAM aspirations would be? In other words, they walk in here and you were to ask them how many of you would want to do a career in STEAM. What would you predict them to be?

AM:
[00:09:54] I would say 30%.

LA
[00:09:56] And why would you say that?

AM:
[00:09:57] Because... we were starting to immerse them so they were little bit higher than other schools. And also, the teachers they had at that point… like Mr. Dean, myself, Mr. Rodriguez. We try to connect it to their broader environment, their daily life. And they were exposed more to the science of living of how things work in their life.

LA:
[00:10:29] Given that for your students what appears to be important for their science aspirations - families attitudes, their own experience of science, self-concept in science- how would that change, or would that change, in any way that you teach your science and math right now?

AM:
[00:10:44] Yes, and it would definitely change. I would... I would try to bring parents in at Back to School Night or whenever I can. Conferences. And talk to them about the importance of science and how it is available for everybody, not just a certain part of the population.

LA:
[00:10:59] Do you think they would believe you?

AM:
[00:11:03] If I showed them my background. They believe me because of my background.

LA:
[00:11:05] Where did you go to school.

AM:
[00:11:07] This is my home school. Griffith. I went to Garfield. So that's part of why my students were a little bit more enthusiastic.

LA:
[00:11:13] Because you were a role model?

AM:
[00:11:15] Yes.

LA:
[00:11:15] You know what… and that's actually one of the things we need to talk about. Okay. Does your science curriculum that you teach, does it account for things like the family attitudes, about that their own self-belief in science...

AM:
[00:11:31] No.

LA:
[00:11:34] If you could make changes?

AM:
[00:11:37] Yes, I would include that aspect of science, of the home. Science of the living. The science of cultures. I would incorporate that more into the curriculum about attitudes… of how things become positive when science is a factor in our lives. That is the lacking.

LA:
[00:12:00] The last thing is interventions. Have you, are you aware of any intervention programs... well your whole school is an intervention. But are you aware of an intervention program, external to your school, working with STEM? Like perhaps before you guys started your STEM initiative here.

AM:
[00:12:18] Not that I know. But I know there are workshops that that are available for them - for free - because of their economic background, where USC does coding over the summer for lower economic backgrounds of children. They recruit from the elementary schools. From here, Cal State LA has a program that recruits for robotics.

LA:
[00:12:42] Do you think they're effective?

AM:
[00:12:43] Yes,

LA:
[00:12:45] Why would you think that?

AM:
[00:12:46] Because the students that I've noticed come back loving and learning science - quite more extensively - and continuing those programs that we have here. Because we have robotics. So those classes tend to fill up faster because of that.

LA:
[00:13:00] I see. So, it's early intervention and bringing them in ...

AM:
[00:13:04] It's expanding the horizons in terms of science and the love that children are having for it.

LA:
[00:13:08]. Perfect. This is great. I'm glad you had time to meet with me. Last thing. Is there any other thing insight the you'd like to offer regarding to your students' science aspirations? Is there something that should be looked at or that you think is important to their science aspirations?

AM:

[00:13:36] I think, you know more money for them to be able to go out and explore a lab, a real lab, in some multinational company. A pharmaceutical lab or a hospital lab, or a pathology lab. Money for field trips. So, the ability for us taking them, exposing them to it, would help quite a lot.
Some of the stuff that I used to do is I used to take them to the Hyperion Plant. Or I used to take them to the plant out here in San Gabriel, the water treatment plant. And they used to love that. And they love those types of things, because they would see how the water would come in disgusting. And come out clean to drink.

LA:
[00:14:31] Why is that not available anymore?

AM:
[00:14:33] Funds dry up. And it's harder to take kids on field trips because of the fact that there's not a lot of loopholes now, with medical and social and mental. We need all kinds of different support now, on all the trips. It's harder now.

LA:
[00:14:50] That's unfortunate. Well, I appreciate the time you've given me here. Thank you.