SCIENCE ACHIEVEMENT OF NON-NATIVE ENGLISH SPEAKERS: A LONGITUDINAL, HIERARCHICAL LINEAR MODELING PERSPECTIVE

by

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(Under the Direction of Mary M. Atwater)

ABSTRACT

This study was conducted using a nationally representative sample of Non-native English Speaking (NNES) students to estimate effects of certain student, family, and school variables on the science achievement of NNES Students. Hierarchical linear modeling was used to estimate effects of parental, school, and student variables on these NNES students' science achievements. The estimate three level growth models included variables associated with student background characteristics (i.e., race, gender, and socioeconomic status); the school (i.e., school science instruction emphasis, number of certified ESL teachers); family (i.e., number of book at home, language spoken at home); and students (i.e., time spent on science homework, ESL enrollment). Responses to questions from a large, nationally representative dataset, the National Educational Longitudinal Study of 1988, were employed to test the model.

It is found that from base year to the second follow-up, NNES students' science achievement increased as students progressed in grade level. More home literature, more parental involvement and better home environment are good predictors of NNES students' science achievement and achievement growth. Background and socioeconomic status (SES) affect NNES students' achievement, but these variables only partially explain the level of science achievement attained. Proper parents' guidance and school efforts would aid in closing the achievement gap.

INDEX WORDS: Non-native English Speaking students, Science Education, Hierarchical Linear Modeling

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B.S. Beijing Normal University, P. R. CHINA, 2002

A Dissertation Submitted to the Graduate Faculty of The University of Georgia in Partial Fulfillment of the Requirements for the Degree

DOCTOR OF PHILOSOPHY

ATHENS, GEORGIA

2008

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December 2008

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# CHAPTER ONE

# INTRODUCTION

## *Background*

In recent years, there has been a rapid increase of students in K-12 classrooms whose first language is not English. According to data from 2000 census, 3.4 million students were Non-native English Speaking (NNES) students, representing six percent of all school-aged children (U.S. Bureau, 2000). NNES students may have sufficient difficulty speaking, reading, writing, or understanding English to deny them the opportunity to learn successfully in English-only science classrooms.

In January 2002, President Bush signed into law the No Child Left Behind Act (NCLB) — the most sweeping reform of federal education policy in a generation. The most ambitious goal in the education history of the United States was set: closing the achievement gap between White and “minority” students by 2013-2014. Consequently, student achievement would not be measured in averages. States are required to report achievement data by student subgroups (major racial/ethnic groups, low-income students, students with disabilities, and NNES students), some of which are historically low-achieving. Schools that do not provide quality education to NNES students can no longer afford to do so, but it is overshadowed by the fact that the majority of NNES students will be forced to take an exam in a language in which they are not yet proficient (Wright, 2005).

At the core of No Child Left Behind are measures designed to close achievement gaps between different groups of students (Wright, 2005). How to best close NNES students’ gap in science achievement is an important question to teachers, principals, and parents. Over the last 30 years, elected officials, education agencies, and the courts have established guidelines for the education of these students. Federal requirements allow states a wide range of latitude in selecting the most effective programs for their NNES students. Many states have enacted their own laws governing the management and style of programs for NNES students. These laws have been developed in cooperation with, or under coercion from, federal agencies or activist organizations. The result has been a patchwork of laws and regulations that can vary greatly from state to state. Education policies for NNES students must be grounded in sound pedagogical principles, and not politics or ideologies.

Current immigration data (U.S. Census Bureau, 2004) indicate that the ethnic and linguistic backgrounds of immigrants are more diverse than in the past. The number of "language-minority" children in the U.S. has doubled over the last 20 years (NCES, 2003). Thomas and Collier (1997) found: In 1988, 70% of U.S. school-age children were of Euro-American, non-Hispanic background; But by the year 2020, U.S. demographic projections predict that at least 50 percent of school-age children will be of non-Euro-American background; By the year 2030, language minority students (approximately 40 percent), along with African-American students (approximately 12-15 percent), will be the majority in U.S. schools; By the year 2050, the total U.S. population will have doubled from its present levels, with approximately one-third of the increase attributed to immigration. Schools in the United States face considerable pressure to develop effective learning environments that incorporate students with varied experiences with educational systems, immense linguistic diversity, and a myriad of language levels and prior academic experiences.

Both socioeconomic and sociocultural perspectives have traditionally guided research into the links between language status and student achievement (Rumberger & Larson, 1998). That is, attempts have been made to explain underrepresented students' academic achievement from background characteristics of their families (e.g., socioeconomic status, parents' highest education) (Chavkin, 1996; Minicucci & Olson, 1992); the student themselves (e.g., ethnicity, gender) (Fleischman et al., 1996; Minicucci & Olson, 1992); and from characteristics ascribed to them (e.g., ability, self-esteem, motivation) (Slavin & Cheung, 2003). Other studies have sought to explain varying graduation rates among minorities by looking at factors inhibiting or enhancing their persistence in high school and college (Hodgkinson & Outtz, 1992; Rumberger & Palardy, 2005).

While background and socioeconomic status (SES) undoubtedly affect underrepresented students' achievement, these variables may only partially explain the level of academic achievement attained. Furthermore, they may merely play an indirect role in explaining the phenomenon in relation to other causal factors. If this hypothesis is true, studies focusing on student background characteristics alone may result in the labeling of students as "at-risk" by virtue of their membership in an underrepresented group, with no regard for their actual ability. Models focusing on background characteristics of students alone often cannot explain students' academic achievement; reliance on these models seldom lead to improvement in educational service delivery since backgrounds of students are difficult, if not impossible, to change.

The model presently proposed in this study includes student background variables as possible explanations of student achievement. Also included are measures of school and home environment, teachers' instruction, and parental involvement, as well as measures of students' aspirations and motivation. All are believed to be related to student achievement.

Also research on non-native English speaking students in science education is a new and developing field; studies have been conducted from a range of theoretical and disciplinary perspectives (Lee, 2005). Although the studies have used a variety of research methods, many were conducted using qualitative methods, whereas experimental or quasi-experimental studies were rare (e.g., Dixon, 1995; Rodriguez & Bethel, 1983). No meta-analysis of statistical research studies was found in the literature (Lee, 2005). The majority of studies are small-scale, descriptive research conducted as single studies by individual researchers; relatively few intervention-based studies are on a large scale (e.g., Amaral et al., 2002; Hart & Lee, 2003; Lee, 2004; Stoddart et al., 2002).

This study was conducted using a nationally representative sample of NNES students. Data were collected during the base year of the National Center for Educational Statistics (NCES) National Education Longitudinal Study (NELS) of 1988 and the first (1990) and second follow-ups (1992). One salient weakness of the data is that it is getting a little old. To some degree, the U.S. educational process has changed in the past years as has U.S. society and thus any inferences from NELS may be dated to some degree and may not cross-validate well on present-day data. However, NELS: 88 surveyed approximately 25,000 students in 8th, 10th, 12th grades and their teachers. The sample is nationally representative to allow generalization to the whole population. Multiple-choice science test scores are available for the 8th, 10th, 12th grades, which allow us to examine the grade difference of NNES students' achievement. NELS: 88 include broad information on teachers, students and parents, allowing us to control for factors influencing NNES students' achievement for an accurate assessment. All these make it still an excellent data source for addressing the research questions in this study. Hierarchical linear modeling, a method for analyzing nested data, will be used to estimate direct and indirect effects of parental, school, and student variables on these NNES students' achievement.

*Problem Statement*

Why can many NNES students not achieve at levels comparable to those of native English-speaking peers? Students who are NNES face a range of challenges in learning science, the most obvious one being that they have to learn a new language at the same time they are asked to master demanding new subject matter. Language minority students are often placed in mainstream, English-medium classrooms long before they develop the degree of language proficiency necessary to compete on an equal footing with native speakers of the school language (Harklau, 1994). The NNES student may be placed in a science class in which no one, including the teacher, understands the student's native language. Also, some NNES children are recent immigrants (Lollock, 2001) who received little or no formal schooling in their homelands and must cope with the additional daunting tasks of adapting to a new culture and an unfamiliar educational system. Other NNES students are U.S. citizens whose cultures differ from that of their school or who may have had scant exposure to science in the home (Barba, 1998). The nature of science presents additional obstacles. Science has a unique vocabulary, with terms that an NNES child is unlikely to encounter in other contexts or in English as a Second Language instruction. Besides, good reading ability is a must for science learning (Norris, 2003).

For some underserved families, cultural or language differences that they encounter in society and school are not only barriers to overcome, but also markers of identity to be maintained (Ogbu, 1992). While "acting White" has been proposed by Ogbu in mid-80's, the students may not be able to resist their own cultural values, mores, and practice's influence. The assimilation of many immigrant groups often remains blocked (Portes & Zhou, 1993). Children of Asian, black, mulatto, and mestizo immigrants cannot escape their ethnicity and race, as defined by the mainstream; Their enduring physical differences from whites and the equally persistent strong effects of discrimination based on those differences, throw a barrier in the path of occupational mobility and social acceptance; Immigrant children's identities, their aspirations, and their academic performance are affected accordingly (Ports & Zhou, 1993).

There is no doubt that home culture deeply influences children's learning (Beane, 1995). For the past two decades, educators have looked at ways to develop a closer connection between students' home cultures and the school. This work has had a variety of labels, including "culturally appropriate" (Au & Jordan, 1981), "culturally congruent" (Mohatt & Erickson, 1981), "culturally responsive" (Cazden & Leggett, 1981), "culturally compatible" (Jordan, 1985), "culturally relevant" (Ladson-Billings, 1995), and "multicultural" (Banks, 1993).

However, research focuses primarily on English language proficiency, with limited attention to subject area instruction such as science (August, Carlo, Dressler, & Snow, 2005; Lee, 2005). International and national studies on science achievement indicate poor science performance of U.S. students overall and persistent achievement gaps between advantaged and underrepresentative students within the United States (Campbell, Hombo, & Mazzeo, 2000; National Center for Education Statistics, 1997). NNES students were excluded from most large-scale assessments until very recently (Lee, 2005). Researchers have suggested that teachers must accommodate these students if LEP students are to increase achievement (Mason & Barba, 1992; Atwater, 1995). Only when schools respect NNES students' experiences and values they bring from their home and community environment, and provide adequate educational resources and funds to enable them to achieve the same level of achievement as the mainstream students, they can be considered to be provided the equitable learning opportunities

(Lee, 2003). An examination of the literature on effective NNES content area instruction shows that certain practices have been repeatedly recommended. These practices include the use of hands-on learning, cooperative learning, and building new knowledge on prior student knowledge through the use of culturally relevant examples (Fradd & Lee, 1999; Bailey, 1997). Also when learning science, NNES students must learn how to read text that is organized differently than that in other core subjects (Rogers & Rogers, 2000)

*Theoretical Framework*

Postpositivism has not just influenced how the body of this thesis is understood; actually, most of the theoretical perspectives presented in this thesis are influenced by postpositivist thought. In the postpositivist paradigm, the reality is assumed to exist, but to be only imperfectly apprehensible because of the basically flawed human intellectual mechanisms and the fundamentally intractable nature of phenomena (Guba & Lincoln, 1994).

Epistemologically, the postpositivists retain objectivity as an ideal, but recognize that it cannot be achieved in an absolute sense. Postpositivists attempt to approach objectivity by striving to be as neutral as possible by requiring reports of inquiry to be consistent with the scholarly tradition of the field and by subjecting inquiries to review by peers. Methodologically, postpositivism relies on multiplism and triangulation (Easton, 1997). Since human sensory and intellective mechanisms cannot be relied upon, it is essential that the “findings” of an inquiry be based on as many sources—of data, investigators, theories, and methods—as possible. Further, since objectivity can never be entirely attained, relying on many different sources makes it less likely that distorted interpretations will be made (Guba, 1990). Postpositivism also tries to correct some of the imbalances of positivism in the areas of rigor/relevance, precision/richness, elegance/applicability, and verification/discovery by placing more emphasis on the latter word of each pair (Lincoln & Guba, 1985).

In particular, the characteristics of postpositivism refer to those of mutuality and adaptation in a modest manner; those concerned with policymaking, research, and practice focus on the complexity conducive to implementation and, at the same time, to a socially and politically negotiated outcome after the undertaking of implementation (Snyder et al., 1992). This means that the authority of the literature must continue to be respected by the reader, and at the same time, the setting may be modified by each situation. Reality is preoccupied with problems and conflicts that need to be overcome; rigorous thinking and flexibility are both necessary.

### *Research Questions*

Student achievement is not simply a matter of what happens in school. Although schools can and do make a significant difference, research has identified numerous factors that affect student success. It was hypothesized by the author of this thesis that a combination of the factors of classroom practices, school science education policies, and the non-classroom life would influence student science achievement as measured by NELS results.

This study combine characteristics of students, schools, and family backgrounds to identify and systematically examine a much broader range of factors influencing students' science achievement than has been done in previous research. By introducing backgrounds in different years into the study of student outcomes, the longitudinal study will broaden the definition of context considered in previous studies and examine more thoroughly which factors improve or hinder students' educational outcomes. Moreover, by illuminating specific school practices and characteristics of family and community environments affecting NNES students, the study does contribute to an informed policy debate and suggest how policy makers and school leaders could facilitate students' success within school and the academic world beyond. This is particularly important since large and growing numbers of students who lack basic English skills are in today's schools.

Thus, the following research questions are addressed:

1. Has the NNES students' science achievement improved during the years? If they did improve, how much improvement occurred?
2. What kinds of learning variables affect NNES students' science achievement and achievement growth?
3. What variables exert the greatest influence on NNES students' science achievement and achievement growth?
4. Do the statistically significant factors found differ for NES students?

# CHAPTER TWO

# REVIEW OF SELECTED LITERATURE

To support this study, a review of literature was conducted. Specifically, the review was conducted in order to (a) examine past research on school learning theory; (b) glean from this body of knowledge which variables appear consistently in present models of school science learning; and (c) substantiate a model of indicators of academic achievement for NNES students.

## *Past Research on School Learning Theory*

In 1983, Haertel, Walberg, and Weinstein discussed eight psychological models believed to be foundational to school learning theory. These models set forth the conditions deemed essential for student learning and are summarized below in chronological order.

*The Carroll model (1963)*. The assumption underlying this model is that students will master instructional objectives to the extent that they are allowed and are willing to invest the time needed to learn the content. Five constructs formed the basis of his model: aptitude, perseverance, ability to comprehend instruction, opportunity to learn, and quality of instruction (Carroll, 1963). It is apparent that three of the five major variables in this model— perseverance, aptitude, and ability to understand instruction—are student characteristics. The remaining two components of Carroll's model—opportunity to learn and quality of instruction—are imposed upon the learning process by the environment, which includes the teacher and the instructional materials, or the "system". The major premise of this model is that school learning is a function of time. A summary of the Carroll's model would look like this: School Learning = $f$ (time spent/time needed) (Carroll, 1963).

According to Richey (1986), Carroll's model is a generalized one that is descriptive in nature and includes consideration of individual learner characteristics, delivery, and the curriculum. One of the limitations of this model is that it fails to include teacher characteristics and classroom planning and management.

*The Bruner model (1966)*. Bruner viewed instruction as the means by which the learner becomes self-sufficient. Of utmost importance to Bruner is an individual's predisposition toward learning. The ideas of self-sufficiency and predisposition for learning correspond to the motivation to learn (Bruner, 1966). Bruner believes that the instructor is responsible for maintaining the proper balance between instruction, feedback, and uncertainty. Instruction was to be based on optimum structuring and sequencing. He also advocates incorporating a system of rewards and punishments as motivators for learning. This model is one of the task-focused models that outline step-by-step procedures for facilitating learning (Bruner, 1966). Bruner has been acknowledged as a major supplement of Piaget's theory of cognitive development. Bruner attempted to extend the scope of the existing theory of cognitive development by creating the "three models of representation" and pointing out the close relationship between cognitive development and theory of instruction. The three models of representation are the following: (a) enactive, in which learners acquire knowledge by action, past events and patterned motor response; (b) iconic, in which learners perceive outside with internal images by using visual and other sensory organizations; and (c) symbolic, in which learners can understand knowledge by language and reason and start trying to solve problems by thinking creatively (Bruner, 1966).

The Cooley and Leinhardt Model (1975). Cooley and Leinhardt focus on the relationship between school practices and school performance as predictors of both academic achievement and student attitudes. Variables being predicted include academic achievement and attitudes toward school, peers, and teachers. Input includes initial student performance. Process includes opportunity, motivators, structure, instructional events, while output includes criterion performance. Thus, school performance is seen as the result of five constructs: initial abilities, opportunity to learn, motivators, structure, and instructional events (Cooley & Leinhardt, 1975). One of the strengths of this model is that, much like Bloom's (1976) model, it considers the role of attitudes in the instructional process. The Cooley and Leinhardt model cites learner attitudes toward school, peers, and teachers as major conditions that affect the outcomes of instruction. One of the major limitations of this model, as well as other time-focused models, is that they often overlook students' individual characteristics.

*The Bloom Model (1976)*. According to Bloom, prior achievement, reading comprehension, verbal intelligence, attitude toward the subject matter, self-concept of the learner, and attitude toward the school are prerequisites for the maximization of school learning. Model of school learning is an input-process-output model. Rather than believing that there are good learners and poor learners, Bloom posits that there are faster learners and slower learners (Bloom, 1976). The model has three categories: student characteristics, instruction, and learning outcomes. One of the strengths of this model is that Bloom considers the role of attitudes in the instructional process—attitudes toward the subject matter, the school, and oneself as a learner. It is also interesting that Bloom's model presents time factors as an outcome of instruction. Learning rate, which is a time factor, is important because learning process skill has been identified as a major goal of instruction, in addition to content area achievement (Bloom, 1976).

*The Glaser Model (1976)*. Glaser's model consists of four components. These include assessment of (a) competencies and skills to be achieved; (b) the initial state from which learning begins; (c) conditions to be implemented to produce change from the learner's initial state to be desired state of competence; and (d) procedures to determine the short- and long-term outcomes of the conditions implemented (Glaser, 1976). Glaser's model indicates that there are many aspects of teaching that are not based on the personality of the instructor, but rather on the intelligent use of information from assessments and instructional results.

*The Harnischfeger and Wiley Model (1976)*. This model emphasizes background characteristics (e.g., of teacher, student, and curriculum/institution), teaching-learning process, and outcomes. Pivotal to their research is the belief that pupil outcomes are mediated through pupil pursuits; the number of courses taken and the total active learning time expended influence pupil outcomes (Harnischfeger & Wiley, 1976). Determinants of Pupil Achievement is based on Carroll's model, but was also influenced by Bloom. It encompasses background characteristics, teaching-learning process, and outcomes. The model recognizes that all pupil outcomes are directly mediated through pupil pursuits. It also emphasizes teacher time and learner time. They include teacher background characteristics as conditions related to student achievement. This model stands out in the group of time-related models in that it includes teacher background characteristics as conditions related to student achievement. This model views both teacher and student time as critical. Also, while it considers individual learner characteristics, the model is geared more to total classroom instruction (Harnischfeger & Wiley, 1976).

*The Gagné Model (1977)*. Gagné proposed that learning proceeds through eight phases: activating motivation, informing learner of objectives, directing attention, stimulating recall, providing learning guidance, enhancing retention, promoting transfer of learning, and eliciting performance and providing feedback. This theory stipulates that there are several different types or levels of learning (Gagné, 1977). The significance of these classifications is that each different type requires different types of instruction. Gagné identified five major categories of learning: verbal information, intellectual skills, cognitive strategies, motor skills, and attitudes. Different internal and external conditions are necessary for each type of learning (Gagné, 1977). For example, for cognitive strategies to be learned, there must be a chance to practice developing new solutions to problems. To learn about attitudes, the learner must be exposed to a credible role model or persuasive arguments. Gagné suggested that learning tasks for intellectual skills could be organized in a hierarchy according to complexity: stimulus recognition, response generation, procedure following, use of terminology, discriminations, concept formation, rule application, and problem solving. The primary purpose of the hierarchy is to identify prerequisites that should be completed to facilitate learning at each level. Prerequisites are identified by doing a task analysis of a learning/training task. Learning hierarchies provide a basis for the sequencing of instruction (Gagné, 1977).

*The Bennett Model (1978)*. Bennett attempts to explain factors affecting success in school learning at the primary level by using concepts that generate practical research questions. He outlines a six-variable model of school learning: amount of coursework, time allocated to curriculum activity, total active learning time, total content comprehended, achievement on curriculum tasks, and feedback (Bennett, 1978). Like Bloom, Bennett has added the feedback component to his model, which is not directly considered in the Harnischfeger and Wiley or Carroll models (Haertel, Walberg, & Weinstein, 1983).

After these models, several researchers summarized much of what was known about increasing test scores (Cruickshank 1985; Proctor 1984). At the same time some researchers were focused on accounting for all the factors related to school achievement, others developed models of effective teacher practice (Rosenshine, 1995; Slavin, 2003). However, the eight classic models summarized by Haertel, Walberg, and Weinstein were instrumental and fundamental in the construction and advancement of school learning theory. As the data used in this thesis were first collected in 1988 and these eight models were the most influential school learning theories those days, it is believed by the author that these eight psychological models had influenced the survey designing and the whole data collection process. Thus, it is important for us to examine these classic models here.

However, these models merely represent a starting point for future research. They successfully document the importance of six of the ten variables currently proposed: (a) prior measures of aptitude or achievement, (b) teacher quality and quality of instruction, (c) student attitudes and aspirations, (d) student motivation/time spent on coursework, (e) the school and classroom environment, and (f) feedback on or measures of later stages of achievement. There is a continuing need for research testing specific variables falling within these broad constructs. Research is also needed which includes parental influences and background characteristics of students. Moreover, given that school achievement is a dynamic and interactive process, research on both direct and indirect effects on achievement is needed in order to "promote understanding of their catalytic or suppressor effects" (Keith & Benson, 1992).

### *Variables that Influence Students' Science Achievement*

After reviewing recent studies, the literature is summarized as follows. There are four primary categories of factors that are thought to affect students' science learning: (a) school and classroom factors; (b) students' variables (e.g., science interest, attitude, motivation); (c) background characteristics (e.g., gender, race/ethnicity, socioeconomic status); and (d) family and community factors.

*School and classroom factors*

Most of middle and high school students' studying occurs in school. Their school lives have a large impact on their science learning. Factors that influence their learning include the science curriculum, the classroom learning environments, teachers' teaching strategies, hands-on activities, technology implementation, and the role of the principal.

The role of the curriculum in science learning is crucial. An appropriate science curricula that promotes high quality learning is desirable for all learners (Parkinson, 1994). The traditional curriculum model assumes that students should first learn fundamental facts and skills, and then combine them at some later point to solve problems. This approach has led to curricula that emphasize facts, laws, and rote learning. It also conflicts with the goals of education for the 21st century, when citizens increasingly need to think critically and strategically to solve real-world problems using knowledge from multiple disciplines (Parkinson, 1994). The national standards for science education require educators to align their science curricula with the standards for both science and other disciplines. The resulting curricula should present science holistically, linking concepts and processes across discipline and articulating them throughout students' years in formal schooling.

Classroom environment (also referred to as climate, atmosphere, tone, ethos, or ambience) is important and influential in terms of students' learning (Fraser & Walberg, 1995). Time, space, and materials are critical components of an effective science learning environment that promotes sustained inquiry and understanding. Teachers must be given the resources and authority to select the most appropriate materials and to make decisions about when, where, and how to make them accessible. Such decisions balance safety, proper use, and availability with the need for students to participate actively in designing experiments, selecting tools, and constructing apparatuses, all of which are critical to the development of an understanding of inquiry (National Science Education Standards, 1996).

Good teaching strategies and practices have been shown to be effective in improving student achievement. Wenglinsky (2002) has found that the effects of classroom practices, when added to those of other teacher characteristics, are comparable in size to those of student background, suggesting that teachers can contribute as much to student learning as the student themselves. All of those effective strategies and practices have one thing in common—they keep students' attention focused on learning. Practices supported by research include learning cycle approaches, collaborative learning, analogies, wait time, concept mapping, computer simulations, microcomputer-based laboratories, systematic approaches to problem solving, conceptual understanding in problem solving, science-technology-society, real-life situations, and discrepant events (Cawelti & Gabel, 1999).

Instead of just memorizing facts, hands-on science will help students to develop meaningful understandings of science. Meaningful understanding results from the learner building meaningful relationships and connections between ideas and blending personal experiences with more formal scientific knowledge (Anderson, 1987). Imagine a child learning the concept of water and being able to tell why water is different from alcohol, milk, and other liquids. Meaningful understanding is useable knowledge that can be applied to solve a problem in a variety of different situations and contexts. Meaningful understanding is enabling—it enables students to use what they know.

Technology can also help transform the science classroom into an environment in which learners actively construct knowledge (Linn, 1997; Tinker & Papert, 1989). Using technology in project-based science lessons makes the environment more authentic to students because students can use the computer to access real data on the Internet, expand interaction and collaboration with others via networks (such as e-mail), use tools to gather data (such as light and heat probes that are plugged into computer ports to conduct experiments), employ graphing and visualization tools to analyze data, and produce multimedia artifacts. Finally, the multimodal and multimedia capabilities of technology make information more accessible not only physically (easy access for obtaining and gathering information into one's understanding) (Blumenfeld et al., 1991).

Regarding the role of the principal and its impact on student achievement, strong administrative leadership is typically a key component of schools with high student achievement. Many leadership traits and behaviors are positively related to student achievement, attitudes, and social behavior (Cotton, 2003). Some urban systems have reduced the number of central office people, but all of the districts studied also have substantially alternated the kind of roles these people play. The diversity of the school population and the demands inherent in the urban environment make the work more demanding (Cotton, 2003).

*Students' variables*

Learning is a very complex process. When learning is defined as a process in which the learner actively constructs meaning out of real and vicarious experiences, its dynamic nature and complexity are portrayed. Only the learner can make the decision to learn. Laboratory work, community resources, and educational technology can enhance learning only if they provide meaningful contexts for the learner (Barnes, 1989). Blocks to learning are minimized when the classrooms are the place to "do science" in ways which individual learners understand. Low self-esteem, emotional problems, lack of motivation, poor study skills, peer pressure, and insufficient prior knowledge are all possible factors that block the learning of learning.

Poor attitudes toward learning science can be found among students who are poor achievers, average students, and high achievers (Fraser & Walberg, 1993). However, the review of the research evidence offered little support for any strong relationship between attitudes and achievement; there is some disagreement about the nature of the causal link and whether it is attitude or achievement that is the dependent variable (Osborne, Simon & Collins, 2003). Research clearly shows that early childhood experiences serve as a major influence on academic interest; feelings of enjoyment and interest in science combined with success in junior science courses are likely to lead to a positive commitment toward science that is enduring (Osborne, 2003). This only means there is a possibility that some children can achieve highly in science without holding a positive attitude towards it. However, lack of a positive attitude towards science will indicate that the students are not likely to continue selecting to take more science courses (Atwater, Wiggins & Gardener, 1995; Hill, Atwater, & Wiggins, 1995).

Positive cognitive outcomes are most likely to occur when learning is self-directed and intrinsically motivated (Ryan, Connell, & Deci, 1985). Several attitude change interventions have been evaluated in recent years, such as activity-based practical work, learning cycle classes, jigsaw cooperative learning groups and etc.; Among the interventions being researched, those that engage learners in hands-on science activities and that stress the relevance of science through issue-based experiences tend to succeed (Koballa & Glynn, 2007).

More than 130 studies support the obvious idea that the more students study, other things being equal, the more they learn. This is one of the most consistent findings in educational research (Cawelti & Gabel, 2004). Time alone, however, does not suffice. Learning activities should reflect educational goals. The textbooks, materials, learning activities, tests, and other outcome assessments should be well matched in content and emphasis (Cawelti & Gabel, 2004).

Research also has verified the importance of building on students' prior knowledge when helping them to learn new concepts. This approach verifies not only the importance of articulating students' science experiences from kindergarten through grade 12, but also the importance of aligning students' science experiences with their other experiences both inside and outside of school (Beane, 1995). Educators should keep in mind that the development of a child involves multiple settings—the home, the neighborhood, the school, and the workplace. People learn and grow in all of these settings. Students of all ages construct meaning about themselves and their world out of personal experiences, including the influences of culture (Beane, 1995; Caine & Caine, 1991). Learning is enhanced when curriculum and instruction integrate student experiences with the development of meaning. Iran-Nejad, McKeachie, and Berliner (1990) describe this concept: "The more meaningful, the more deeply or elaborately processed, the more situated in context, and the more rooted in cultural, background, cognitive, and personal knowledge an event is, the more readily it is understood, learned, and remembered". Just as existing knowledge determines the kind of scientific activity in which students can engage, it also determines the way in which they respond to new ideas and information. Ausubel (1968) expresses this idea: "If I had to reduce all of educational psychology to just a single principle, I would say this: find out what the learner already knows and teach him accordingly". Once we know the kind of understanding that learners already have, we can begin to design learning strategies to ensure that they shift in the direction we desire; the necessary step appears to be finding out where learners currently are.

*Background Characteristics*

Culture, ethnicity, socioeconomic status (SES) and parents' highest level of education are all salient factors influencing students' science achievement. Variations within immigrant groups from the same country of origin can be based on education, social class, the immigration experience, religion, and individual differences. Students whose parents are university-educated have been shown to perform approximately two-thirds of a proficiency level higher than those whose parents had no more than a high school education (Jacobson & Williams, 2000). Both theory and evidence suggest that students' knowledge and behavior, including academic outcomes, are influenced by the characteristics of the schools they attend (Hodson, 1998). All things equal, as student SES increases, so does student achievement (Sirin, 2005). This does not mean that poor or underserved children cannot learn. However, social class and economic condition are important factors related to success and cannot be ignored. Different teaching strategies and parents' guidance are believed to aid in closing the achievement gap.

Tracking systems should be dismantled entirely, as they provide a watered-down or remedial academic curriculum (Lucas, 1999). Oakes (1985) found that students in higher tracks spend more time learning and getting more qualified teachers than do students in low-level tracks; yet, when they are placed in mixed groups, higher-achieving students do just as well as they did in the homogeneous classes, and struggling students performed better. No students should be placed in tracked classes regardless of their race, SES, or prior achievement.

Also, teachers should be prepared to teach effectively diverse student populations and provide culturally relevant instruction to their students. For example, failing to understand the cultural style of some African Americans may cause teachers erroneously to conclude that these students have limited critical thinking and reasoning abilities (Ladson-Billings, 1995); the reluctance of Native American children to operate on a tightly controlled time schedule and engage in highly individualistic and competitive activities may be misinterpreted as lack of initiative, motivation, and responsibility (Greenbaum, 1985). The more a teacher understands the cultures and other aspects of diversity in a classroom, the more likely the teacher can provide a classroom context that will result in successful, high-quality education for culturally and linguistically diverse students (Ladson-Billings, 1995).

A substantial number of studies have taken place over the past three decades to identify factors describing individual schools that have defied the odds by accomplishing high levels of achievement while serving significant numbers of children from low-income homes or families from underrepresented groups. Some researchers believe there is a relationship between SES and achievement depends on the size of the school (Lee & Smith, 1997; Coladarci, 2006). Until recently, however, there has been little research focused on school districts as the locus for improvement efforts. The combined factors of high mobility among low-SES children and the misalignment of curriculum factors are also factors to be consented. Latitude has been given, however, on particular strategies to be used in improving achievement (Cawelti & Gabel, 2004). As an example, to address school stability issues of homeless children, Congress passed the McKinney-Vento Homeless Education Assistance Act. This legislation allows homeless students to remain in their original schools, even if they no longer live in the residency area, and requires schools to provide transportation.

Research indicates that females are receiving a significantly poorer science education than are males, even when they are in the same classroom in U.S. The consequences of this poorer education can be seen in gender differences in attitude toward science and differential course enrollment patterns. Females hold more negative attitudes toward science than do males and are less likely to continue studying science in high school and beyond (Baker & Leary, 1995). Many teacher behaviors and teaching strategies have been identified that contribute to these problems. Teachers may pay more attention to male students because they aggressively, seek, give, and obtain information (Linn & Hyde, 1989). These characteristics provide male students with more opportunities to receive advanced information on a subject. It has been hypothesized that teachers see this aggression as intelligence, not as a gender-based difference. Because this occurs at an early age, female students are quickly excluded from receiving advanced information. The long-term effect of this type of teaching is that females have to be more aggressive throughout life to get as much as their male counterparts in terms of career and salary advancement (Linn & Hyde, 1989). However, females are also less likely to believe that science will be useful for their future employment and education (Linn, 1997). They are more likely to report lower levels of interest and enjoyment in science.

The role of gender has been particularly under-theorized in studies of immigrant children (Suarez-Orozco & Qin, 2006). At the precollege level, researchers have found strong gender differences in grades, academic engagement, high school completion, and future aspirations for immigrant students. Gibson (1993) found that Mexican girls did better than boys in terms of grades and attitudes toward school. Portes and Rumbaut (2001) found that Latino and Asian boys were less engaged, had significantly lower grades, and lower career and educational goals than did girls. Other researchers found similar gender trends in their study of children from immigrant families (Kao & Tienda,1995; Rumbaut, 2005).

Researchers have found that until third grade, an equal number of boys and girls show interest and feel confident in learning science. By fourth grade, 74% of the girls and 81% of the boys say they like science. These numbers continue to decrease throughout middle school, and by eighth grade 64% of the girls compared to 72% of the boys say they like science. By their senior year in high school, only 57% of the girls compared to 74% of the boys show interest in science (Jones, Mullis, Raizen, Weiss, & Weston, 1992).

Investigators have developed various explanations for the significant decrease in girls' interest in science through their school years. Feminist scholars (Harding, 1986; Keller, 1992; Kelly, 1985; Kleinman, 1998; Salner, 1985) postulate that the "male" characteristics of science as currently practiced make its pursuit by girls unattractive. According to Kelly, the portrayal of science as masculine affects a child's gender identification. She contends that science as an intellectual domain is perceived as masculine and that this perception discourages girls from expressing interest in science, from doing well in science, and from continuing to study science.

Others have investigated the role that the family (Huston, 1983; Matyas, 1985; Oakes, 1990; Tracy, 1987) and school (Kahle, Andersen, & Damnjanovic, 1991; Oakes, 1990; Roth, 1996; Shepardson & Pizzini, 1992) play in the socialization of children into gender specific roles. Parents tend to buy more scientific games for boys than for girls, and boys are more likely to play with toys that encourage manipulation or construction (Oaks, 1990; Tracy, 1987). According to Matyas, boys' toys and games "tend to emphasize relationships between objects, manipulation of objects in space, grouping, and taking apart and rebuilding of objects" (p. 37). These different opportunities for manipulating objects through childhood play appear to be directly related to spatial ability of boys and girls (Matyas, 1985). In the research on the role of gender in immigrant students' educational adaptation, Qin-Hilliard (2003) found immigrant girls had significantly higher grades in science than boys, and express higher future expectation than boys.

Teachers and the classroom environment also contribute to gender socialization (Kahle, Andersen, & Damnjanovic, 1991; Oakes, 1990; Roth, 1996; Shakeshaft, 1995). Although surveys of teacher responses suggest that they hold similar expectations for the success of both boys and girls in science, actual classroom observations uncover differential teacher expectations for boys and girls in science classes starting in elementary school (Kahle, Andersen, & Damnjanovic, 1991). Boys tend to be encouraged to try again when they fail at something, while girls are allowed to give up (Oakes, 1990). In addition, teachers in science classes tend to call on boys more often than on girls, and the questions they ask boys are usually more challenging than those asked of girls (Roth, 1996; Sadker & Sadker, 1986). Teacher questioning is a very important aspect of student learning and is a good indication of the quality of teaching. Good questions focus students' attention and help develop their critical thinking skills by making them express their own ideas, face their own misconceptions, and question evidence (Roth, 1996).

In 2000, Jones, Howe, and Rua confirmed that girls' attitudes to science are still significantly less positive than boys by using questionnaires with large samples. However, there begins to emerge the signs that, girls no longer had the stereotype of "science is only for men", and have confidence in their capability to undertake science courses (Harvard, 1996; Whitehead, 1996).

Enrichment science programs, which employ a variety of pedagogical strategies such as cooperative learning, inquiry and mentoring, help to narrow the gender gap in science, mathematics, and engineering. For instance, cooperative learning groups have shown to be particularly successful with females who tend to dislike the competitive aspects of science (Peltz, 1990). Cooperative learning has been found to facilitate student learning in science and improve their attitudes toward science (Bianchini, Holthuis, & Nielsen, 1995; Cannon & Scharmann, 1996; Chang & Mao, 1999; Kahle & Rennie, 1993).

*Family factors*

Parents play an important role in their children's learning. Parents acting as school aids are also a factor that can influence students' achievement. Advantaged students—students who are White, have college-educated parents, come from middle class families, and live with both biological parents—perform better in schools (Jacobson & Williams, 2000). Learning is enhanced when schools encourage parents to stimulate their children's intellectual development (Cawelti & Gabel, 2004). When schools work together with families to support learning, children tend to succeed not just in school, but throughout life. In fact, the most accurate predictor of a student's achievement in school is not income or social status, but the extent to which that student's family is able to (a) create a home environment that encourages learning, (b) express high (but not unrealistic) expectations for the children's achievement and future careers, and (c) become involved in the children's education at school and in the community (Battiste & Henderson, 2000).

Dozens of studies in the United States, Australia, Canada, England, and elsewhere show the home environment to be a powerful influence on what children and youth learn within and outside of school. This environment is considerably more powerful than the parents' income and education. The U.S. media is a source of news, entertainment, and information. It includes radio, newspapers, the Internet, and television. The media has the ability to spread truthful and positive knowledge or to misrepresent people, events, and data. Unfortunately, many times the latter is the case. The average child will watch 8,000 murders on TV before finishing elementary school. By age 18, the average U.S. people has seen 200,000 acts of violence on TV, including

40,000 murders (Herr, 2007). Moreover, television is responsible for imagery that negatively influences youth (Bush, 1999). Consequently, this imagery has the ability to affect youth identity. Television is an important part of life to many students. Bush (1999) notes that, "negative images presented in all of the media conspire with many hours of television viewing to produce a negative effect on Black children's self-image".

Little is known about the media that immigrant youth consume and about how these media may shape their understandings of themselves and their new country. In her longitudinal research about Immigrant Student Adaptation Study to examine media use patterns among immigrant, Louie (2003) suggest that the levels of media ownership within immigrant youth homes are similar to levels found for the U.S. youth population as a whole; but immigrant teens are dissimilar to other U.S. teens in numerous respects. For instance, teens with immigrant backgrounds appear to watch TV more often in the company of siblings and parents. This use pattern suggests that the impacts and experience of media use could differ between immigrant and other U.S. teens, because the type of content one consumes and the meanings one derives from media are often influenced by the values and behaviors of those in the surrounding context (Louie, 2003). More needs to be learned about the types of media content immigrant teens consume, discuss, and retain compared to other U.S. youth, as well as what they consume when they are by themselves compared to what they consume when they are with others. Researchers also suggest that immigrant students not watch TV especially for language learning (Zhou & Cai, 2002).

Youth in the United States spend approximately 900 hours per year, on average, in school; however, they spent approximately 1500 hours per year watching television (Herr, 2007). Several problems can occur when students spend too much time watching television, such as limiting the time they spend studying. The first problem involves unmonitored, negative influences caused by low-quality programming. These negative influences include hardness, cruelty, violence, crassness, and sexuality. The second problem is that students often miss other activities fundamental to their physical, social, intellectual, and emotional development, such as playing with friends and reading. Television watching may have a useful role to play in students' lives, but it is no replacement for caring and active involvement with other people. The negative relationship between school performance and hours of television viewing was discovered in the 1980s; this was the first time that excessive TV watching was named as the worst factor affecting student science achievement. Parents should limit the amount of television their children view on school nights and help children to select programs appropriate for their ages. It is recommended that parents watch television with their children and discuss the programs with them.

Parents serve as a model for learning and should determine the educational resources available at home. They should read to their children, whatever their ages, as often as possible. Parents should go with their children to the library and make reading a family activity. If parents show their children that they value reading and learning, it is more likely that their children will also value them. Having more reading materials at home, such as encyclopedias, newspapers, and magazines, may help children form the habit of reading. Books are the main educational resources at home. Relative to other countries, the United States has a large percentage of students with a high level of home educational resources. Having more types of books at home indicates a better study environment for the family (with the exception that some parents like to buy books that no one is expected to read). As several studies and reports have shown in recent years, middle and high school students often lack the skills and motivation to decipher the more complex reading materials demanded by upper-grade academic disciplines

(Barnes, 1989). Sometimes students need parents' instruction or guidance to select books to read. Studies also show that when parents read with their children, especially during the preschool years, this exposure to print is directly related to their children's reading success.

The complexities involved in student learning should be recognized. However, one thing that needs to be firm is that all students regardless of age, gender, or cultural/ethnic background should have the opportunity to attain high levels of science education. Equity doesn't mean equal. Science education should include the use of culturally relevant content. Atwater (1995) proposes several ways of integrating culturally relevant content into the curriculum. Also science instruction should not be isolated from students' everyday life. The active role of the learner in constructing language should be emphasized. When students can participate in and observe science in the ordinary world in which they live, they are more likely to learn and to appreciate science as a way of knowing. Both educators and parents should carefully select and use combinations of practices that together increase the probability of helping students learn, with the understanding that these practices may not work in every situations (Cawelti &Gabel, 2004).

*A Model of Science Learning and Achievement for NNES students*

There are many different terms used to describe such students. For the purposes of this dissertation, I have chosen to use the term Non-native English Speaking (NNES) to describe a student who is linguistically underrepresented and who, in English, performs at a level below his or her native English speaking peers. These students' English ability makes it difficult for them to benefit from English-only instruction. The definition of NNES is purposely very broad because there is no standard definition (National Center of Bilingual English, 1996).

A review of the literature was carried out to find studies (a) whose unit of analysis was NNES students, (b) which sought to model NNES students' school experiences, and (c) cast these experiences in simultaneous equations. The literature was scant. Thus, in addition to quantitative analysis, the literature review relied on qualitative studies as well. Also, to better constructing the models, many of literature, especially some data given here are around 1990s with the consideration that these literatures should have contributed to the process of the survey design and data collection. The literature as reviewed is categorized below by measures included in the present model.

*Measuring Achievement of NNES Students*

A major controversy reported in the literature centers around the use of standardized tests as proxy measures of ability or achievement for NNES students. According to Chamberlain and Medeiros-Landurand (1991), there are many cultural variables that may influence test results if students are not completely acculturated to the United States, including attitudes toward competition, attitudes toward the importance of the individual versus the importance of the group or family, a belief in fate versus belief in individual responsibility, gender roles, attitudes toward the use of time, attitudes toward the demonstration of knowledge, verbal communication norms, use of body movements and gestures, proximity, and use of eye contact.

The quality of testing can make a difference for second language learners, and the central problem in assessing English-language learners is their limited ability to perform on a test administered in English. Assessments based on translations into a second language also have questionable validity (August, Carlo, Dressler, & Snow, 2005).

Most national data collection programs have excluded students with limited English proficiency. However, two programs provide relevant information: the National Education Longitudinal Survey (NELS:88) and the National Assessment of Educational Progress (NAEP).

The National Assessment of Educational Progress is a Congressionally mandated achievement test that collects information on the performance of populations and subpopulations of students. Because it is the only assessment that samples both a national and regional cross-section of students in kindergarten through 12th grade, information about the inclusion and participation of NNES students on the NAEP is a relevant source of information on the statewide achievement of NNES students (August, Carlo, Dressler, & Snow, 2005).

The National Education Longitudinal Survey, the primary data source for this dissertation, has been criticized for excluding NNES students who did not have high levels of English proficiency, and as a result, are more likely to drop out of school (Ingels, 1993; National Research Council, 1997). The exclusion of these students has the potential to skew survey results in favor of the more proficient students and to bias policy decisions that are based on the results (Ingels, 1993). However, there are still things to learn from NELS:88 regarding the assessment of NNES students (National Research Council, 1997). The NELS:88 data are still being actively used in the longitudinal study research area .

*Background Variables*

The major background variable included in the present model is SES. Based on 1990 census data, it is estimated that 37% of linguistically underrepresented students live in poverty, in contrast to 17% of the total student population (USGAO, 1994). Immigrant families are more than twice as likely to be poor (1990 U.S. Census, as cited in USGAO, 1994). In 2000, 19 percent or 10.8 million school-age children were children of immigrants, but only 6 percent, or 3.4 million, were LEP. Thus, there are far more children of immigrants than limited English proficient children. In other words, many children of immigrants are not LEP. The census definition of limited English proficient—which we use throughout this report—includes all children who speak a language other than English at home and speak English less than "very well." The census definition, however, only includes spoken English proficiency and is reported by the census respondent—usually a parent or other adult relative (U.S. Bureau, 2000).

The United States is most importantly divided along economic and educational lines rather than race (Hodgkinson, 2000). Two-thirds of NNES students are from low-income families (Capps, et al. 2005). Almost half of NNES students (48 percent) in grades PK–5 have parents who did not finish high school (Capps et al., 2005). In general, states with a high percentage of children living in poverty tend to have a higher dropout rate and a higher rate of teen pregnancies (Hodgkinson & Outtz, 1992). Some NNES students may be perceived to have a low social status because of an increase in anti-immigrant feelings and racial tensions in schools (California Department of Justice, as cited in Minicucci & Olson, 1992). Poverty and related factors, such as high unemployment rates, substandard housing, overcrowded neighborhoods, and health problems can interfere with a student's ability to learn (CCSSO, 1990). According to Hodgkinson, "the number one item which predicts the percent of children who will be at risk of school and health failure is poverty" (Hodgkinson, 2000).

In 2000, two out of three secondary school LEP students lived in linguistically isolated households. High levels of linguistic isolation point up the twin challenges of teaching LEP students and involving limited English-speaking families in their education. Furthermore, linguistic isolation may partially explain why the majority of LEP students in both elementary and secondary schools are U.S.-born (Hodgkinson, 2000).

*School Influences*

Research in the past decade demonstrates that although a school's ability to enable students to succeed depends on its teacher corps, schools with many underrepresented and low-income students are least likely to have highly qualified faculties (Darling-Hammond, 2000; Ferguson, 1998). The very real teacher shortages in many parts of the nation, coupled with some discouraging policies, make it such that fewer well-qualified teachers are available to teach NNES students.

The research in this area of literacy also contends that in classrooms where teachers surround children with literature and give children ample time to engage in the language arts, children will become successful in listening, speaking, reading, and writing (Roser et al., 1989; Tinajero et al., 1998). Large and consistent gaps between the performance of language-minority and language-majority children are traceable to differences in vocabulary knowledge (Snow et al., 2005). NNES students with consistent exposure to a coherent program do better than NNES students who are exposed to many different approaches (Genesee et al., 2006). Effective curriculum incorporates higher order thinking and is grounded in sound theory and best practices (Genesee et al., 2006). NNES students can benefit from reading instruction focused on five components—phonics, phonemic awareness, reading fluency, vocabulary, and reading comprehension—if instruction is adjusted to meet NNES students' specific needs (Genesee et al. 2006). However, programs focused solely on reading at the expense of English language development in speaking, listening, and writing are insufficient to support NNES students' academic success (Callahan, 2006).

Science teachers can make science instruction more meaningful by using hands-on activities which relate science, for example, to real-life activities. The second language learning is facilitated when learner is taught using meaningful input, when new information is presented and linked to already known information, and when the learning environment is relaxed and motivating (Lee, 2005). Manipulatives and hands-on activities are being extensively used in the teaching of math and science. This practice is in keeping with the research in math and science teaching in a bilingual setting that indicates that teaching in the content areas by pairing essential contextual experimentation with academic language learning is necessary for success of the bilingual child (De La Cruz, 1998). De La Cruz also notes in her research that "…to ensure that instruction is at a level where every student can experience success, manipulatives can be used to demonstrate a concept so that new information can be processed" (p. 169).

Teachers' emphasis on using the home language as a medium of instruction and in developing proficiency in two languages is affirmed by the meta-analysis conducted by Greene (1998). Other research reveals that developing literacy in the first language of underrepresented language speakers is essential for later success in English literacy (Krashen & Biber, 1988; Cummins, 1989, 1991; Ramirez et al., 1991; Tinajero, Hurley, & Lozano, 1997). NNES Students with no primary language schooling (either in home country or host country) are not able to reach average grade-level performance (Thomas & Collier, 2002). And high expectations should be positive; hence it expands student potential (Freeman & Freeman, 1992).

When the cultural beliefs and practices of NNES students can not connect with Western science, effective science teaching should help students across the borders between cultures (Giroux, 1992; Snively & Corsiglia, 2001). Thus, NNES students' teachers need to make culture's rules and the norms of classroom behavior clear and explicit. Explicit instruction on academic norms and content in the context of authentic and meaningful tasks and activities has been advocated with nonmainstream students in science instruction (Fradd & Lee, 1999; Lee, 2003).

The research findings of Garcia (1994), Kagan (1989), and Tinajero et al. (1993) note that the importance of cooperative learning practice is essential for Latinos and language underrepresented students of different backgrounds. Huerta-Macias (2002) adds that these learning strategies are more compatible with the social and family structures in which Latino language underrepresented students are most productive.

Garcia (1988), in studying effective classrooms serving bilingual Mexican American students, found that an integrated curriculum, responsive to the linguistic ability of students and implemented by "trained" bilingual (and biliterate) teachers, was common in the 14 classrooms in which students' high standardized achievement test scores were above national norms. Garcia also found that in these classrooms, the children were made to feel that their bilingualism was an academic asset, not something for which either they or their families needed to feel shame.

*Student Influences*

The first factor related to the learner is cognitive skills. An aspect of cognitive skills that needs to be considered is a student's style of learning and the way in which the student processes information (Hamayan & Damico, 1991). The cognitive science perspective sees the relationship between scientific practices and students' sense-making in a complex and reflexive way-as similar, different, interactive, and generative (Brown, 1992; Lehrer & Schauble, 2000). Effective teaching has to examine the everyday experiences and informal language practices that students bring to the learning process; a major problem in science instruction is that teachers are not prepared to recognize the diverse ways in which these intellectual resources can be used in academic settings (Lee, 2005). If the student's home culture teaches him "seeing is believing", that means he prefers to learn science by seeing the real things happened around him (lab activities); but the teacher prefers to teach science by showing how to analyze definitions and develop rules, the student's ability to learn may be hampered by the fact that the information is not presented in the way that he or she needs it.

The second factor related to the learner involves the learner's attitudes, feelings, and personality (Hamayan & Damico, 1991; George, 2003). The theory is controversial, but some researchers (Hamayan & Damico, 1991) believe that if the learner has positive attitudes toward himself or herself, toward English speakers, and toward members of his or her own native language group, then the likelihood of becoming proficient in English may be increased. If the learner has negative feelings toward any of these three, then the likelihood of becoming proficient in English may be decreased. Furthermore, students who have a relaxed, adventurous, and outgoing personality and are not afraid to take risks with English may tend to become more proficient. However, Hamayan and Damico (1991) caution that this proficiency appears to be more in the areas of speaking and writing than in academic areas. The decline of student's attitude scores towards science in secondary school is likely related in some way to the types of science courses in which students are enrolled and the science self-concept that they develop as a result of these courses (George, 2003).

The third factor related to the learner is the learner's proficiency in his or her first language (Hamayan & Damico, 1991). If the student did not go to school in his or her first language and was in the speaking-only level in that language, it is much more difficult for him or her to obtain a higher level in the second language. Without paying attention to the development of the student's first language will severely limits subject area instruction in languages other than English; English proficiency is a prerequisite for science learning (Lee, 2005).

To keep from falling behind their English-speaking peers in academic content areas, such as science, NNES students also need to develop English language and literacy skills in the context of subject area instruction (Lee, 2005). Many states have adopted immersion approaches to English for speakers of other languages (ESOL) or English as a second language (ESL) instruction. For many ESL programs, NNES students spend most of the day in English-only classes, but are removed part of the day for English instruction. About one-third of public schools with NNES student enrollments provide both ESL and bilingual education programs, and 71 percent of all NNES students attend these schools. Thirteen percent of schools (4,832) enrolling NNES students have neither ESL nor bilingual programs, and 3 percent of all NNES students (59,373) attend these schools (NCES, 1997).

As reported by many schools, NNES students have poor attendance, this is reflected by the fact that 20% of language underrepresented students have missed at least two years of high school, and 12% have missed at least two years of junior high (Minicucci & Olson, 1992). These absences may be due to adjusting to a new school culture because different teaching styles, different expectations for student behavior in class, different daily routines, and different relationships between teachers and students. (Minicucci & Olson, 1992).

*Parental Influences*

A study by the National Center for Education Statistics (1992) found that the most important factor in academic performance is the parents' expectations that a student will graduate from high school and go on to college. In mainstream U.S. culture, this expectation may apply equally to males and females, but in other cultures it may not. Educational achievement may not be valued for girls in some cultures or in some families within a cultural group, and this lack of value can affect the achievement of the female students if expectations are lower for them than for male students. In addition, high family mobility resulting from immigration status and migratory work may create a lack of educational continuity (CCSSO, 1990; Minicucci & Olson, 1992; USGAO, 1994).

Parents' involvement is critical to student's educational progress. Parents may become involved by providing a home environment that supports children's learning needs; volunteering to provide assistance in the school as teachers' aides, secretaries, or in other roles; becoming activists and decision-makers in community advocacy groups that advise local school boards and school districts; attending school-sponsored activities; maintaining open channels of communication with teachers and continually monitoring children's progress in school; tutoring the children at home, using specific learning activities designed by the teacher to reinforce work being done in school (Schleppegrell, 2004). Parent involvement in the education of high school students, requires that the parent become co-learner, facilitator and collaborator, a means of support as the high school-age student develops independence and explores future educational options.

However, in 2000, six out of seven LEP children in grades 1 to 5 lived in linguistically isolated households; in secondary school, two out of three did so (U.S. Bureau, 2000). High levels of linguistic isolation point up the twin challenges of teaching LEP students and involving limited English-speaking families in their education. Lack of English proficiency is often cited by school personnel as well as parents as the chief barrier to more active involvement in the schools (First & Carrera, 1988). While many NNES parents do not have the

English language proficiency to engage in many of the typical parent involvement activities, they may be very successfully involved in parent-school collaboration at home. These parents can be taught to reinforce educational concepts in the native language and/or English. Additionally, bilingual community service should be available to bridge language and cultural differences between home and school. An added advantage, of course, is that NNES parents improve their own general knowledge, language and survival skills as a result of their participation in the program (Benner, Mooney & Epstain, 2003).

The role of the parents is critical in the education of the second language learner as the family adjusts to the cultural and linguistic demands of the community and school (González, 1998). Schleppegrell (2004) contends that school and home must both accommodate to the other's needs if LEP students are to be successful. She also notes that teachers' perception of student ability went up after meeting with parents, even when the quality of student work remained unchanged.

Additionally, the parental and community attitudes about English and about English speakers can have a major influence (Hamayan & Damico, 1991). For example, if an NNES student's community values the use of the native language in daily interaction, then that student is more likely not to attain complete proficiency in English because he or she identifies strongly with the native language (Taylor, 1991). Similarly, if the parent or community views English speakers negatively and does not like to interact with them, this attitude may affect the child's proficiency in English (Benner, Mooney & Epstain, 2003).

Another important factor is home literacy in either the first or the second language (Hamayan & Damico, 1991). Native language literacy is one component of cognitive development that affects the acquisition of English proficiency; if the students grow up in an environment where they develop strong native language literacy skills and other skills associated with reading and school, and then they may attain academic language proficiency more easily (Schleppegrell, 2004). The academic proficiency in English may come more easily because the reading skills attained in the first language are similar in some ways to the skills needed to read in English. Several researchers believe that reading skills are transferable from one language to another language (Devine, 1988; Garcia, 1991; Benner, Mooney & Epstain, 2003), so first language literacy is important for second language literacy. It is important to remember, however, that literacy is not the only component of cognitive development involved in attaining academic proficiency. When parents interact with a child in the native language and use it to communicate the native culture and beliefs, other types of cognitive development take place that can aid in the development of academic proficiency in English and offset a lack of native language literacy (Benner, Mooney & Epstain, 2003). Chinese students in the United States are an excellent example of this type of situation. Chinese parents usually use Chinese proverbs and folk stories to motivate their children to study (Liang, Fuller & Singer, 2000).

In general, the majority of NNES students are young Spanish-speaking people (Cuevas, 1996; Navarette & Gustkee, 1996). The Census 2000 Supplementary Survey estimates that over 44 million Americans over the age of 5 speak a language other than English at home, and that for 62% of those 44 million, that language spoken in the home is Spanish (U.S. Bureau, 2000). In spite of NNES students' common difficulties with English, they have a variety of diverse backgrounds that affect their educational needs. These students are not a homogenous group. If educators expect NNES students to succeed academically, they must recognize this diversity instead of treating NNES students alike. As an entire group, NNES students have the potential to make a substantial contribution to the U.S. economy by the time they are old enough to work (National Commission on Testing & Public Policy, 1994). This contribution may be a positive one if students have received a solid education.

This study will contribute to the body of knowledge on achievement or school learning in several ways. First, most studies look at student population overall and make generations to NNES students. Few studies have relied solely on the NNES experience to explain the phenomenon of NNES student achievement. Another unique factor of this study is the fact that it draws from a nationally representative sample of NNES students. While some studies have focused on NNES students, they have been limited both geographically and in terms of sample size. The present study is more rigorous methodogically in that multiple factors of achievement are examined simultaneously using national longitudinal and cross-sectional data.

# CHAPTER THREE

# METHODOLOGY

## *Data Source*

As mentioned earlier, most national data collection programs have excluded students with limited English proficiency. NELS: 88 is one of the two programs provide relevant information for 8th, 10th and 12th grade students.

The National Education Longitudinal Study of 1988 (NELS:88) was a study sponsored by the National Center for Education Statistics (NCES). It followed students who were in 8th grade in 1988 through high school to post-secondary education or work. According to Ingels (1993) and NCES (1995), NELS:88 focused on several issues: (a) school, classroom, family, and community characteristics associated with achievement; (b) the transition of different types of students, including NNES students, from 8th grade to secondary education, and from secondary education to either post-secondary education or to work; (c) the influence of ability grouping and "differential course-taking opportunities" on a student's educational experiences and achievement; (d) factors related to and consequences of dropping out; (e) changes in educational practice over time; (f) the school's role in helping "disadvantaged" students; and (g) the academic performance and school experiences of language-underrepresented and NNES students. Information was collected through sources such as standardized tests, parent and student surveys, attendance records, student transcripts, and teacher evaluations of student performance.

All the data for this study was drawn from the National Education Longitudinal Survey of 1988, a comprehensive survey of students, teachers, schools, and families, designed and funded by the National Center for Education Statistics (NCES). In the spring of 1988, NCES instituted the first stage of a comprehensive longitudinal study, the National Education Longitudinal Study of 1988. NELS: 88 was part of an effort to obtain data relative to students' school experiences and activities, values and aspirations, and family and home characteristics (NCES, 1992). In the 1988 base year, a stratified national probability sample of 24,599 eighth graders attending 1,052 high schools was selected for participation. The database also contained scores of students from cognitive tests in four subject areas (reading, math, science, and social studies). Moreover, data were collected from students' parents, teachers, and school administrators.

The cohort was originally surveyed in 1988. Follow-up surveys were administered in 1990, 1992, 1994, and 2000. More than 75% of the 1988 base year cohort remained active participants through the second follow-up conducted in 1992. The NELS dataset includes excellent background information on each student (including surveys of parents) and uses some of the most advanced testing procedures for assessing students' cognitive abilities (Rock and Pollack, 1995). Extensive background controls are necessary for this study because students represent a diverse population. Unless background differences are adequately controlled, effects of school characteristics and family environments will be mispecified.

*Defining NNES Students*

Information in the NELS: 88 made it possible to identify NNES students in three different ways. First, I defined a student who is NNES if he or she had "ever been enrolled in

English as a second language programs" or "ever been enrolled in language assistance programs", or had received science instruction in a non-English language.

### *Science Achievement*

Science achievement was assessed by the students' IRT-scaled science achievement score in 1988, 1990, and 1992. The science test used in the NELS: 88 contained questions drawn from the fields of life science, earth science, and physical science/chemistry. Emphasis was placed on understanding of underlying concepts rather than retention of isolated facts. This score is vertically scaled to enable measurement of change in achievement during the survey period.

### *Variables Related to Science Achievement*

All of the control and explanatory variables used in this study were listed in Appendix A. The explanatory variables include: student background characteristics (i.e., race, gender, and socioeconomic status); the school (i.e., school science instruction emphasis, number of certified ESL teachers); family (i.e., number of book at home, language spoken at home); and students (i.e., time spent on science homework, ESL enrollment). Coding construct of the explanatory variables in this study can be found in Appendix B.

### *Research Design and Data Analysis*

This study employed a non-experimental, multi-equation design (Pedhazur & Schmelkin, 1991). This permitted examining the impact of the independent variables on the final outcome achievement variable. At the same time, the relationships between the independent variables could be estimated.

Hierarchical linear models (HLM) are a type of model used for analyzing data in a clustered or nested structure. In this study, students were considered to be nested within schools;

in this situation, we would expect that students within a cluster, such as a school, would share some similarities due to their common environment. HLM can be used to analyze a variety of questions with either categorical or continuous dependent variables. In this study, HLM 6.0 was used to analyze the data.

Analysis of longitudinal data using the traditional method of ANOVA or MANOVA is severely limited by the form of data. Perhaps the two biggest problems are (a) all subjects must have an equal number of data points and (b) the data points must have equal data interval. As to the longitudinal survey data collection process in reality, these two requirements are hard to achieve. The traditional listwise deletion discards participants without full data for all time points. This often results in data sets, greatly reduced, biased, and unrepresentative of the original sampled population. To overcome these limitations, this study used a multilevel, random coefficients growth modeling technique, which does not require full data or equal spacing of data and allows for random variation in growth curve coefficients (Raudenbush & Bryk, 2002). Using this approach, all data points will be used in the estimation of growth parameters.

This study relied on school learning theory, previous research, and knowledge of factors associated with science achievement, which was reviewed in the previous chapters.
In this study, a three-level growth model was used to measure the science achievement growth across years. Key features presented in the multilevel model used in this study included: (a) observations are nested in individuals, allowing for different number and spacing of observations across individuals; (b) average achievement, linear growth, and rate of change in growth rates are allowed to vary across schools; and (c) conditional models are formed at the school level, to determine variables of the school that are related to average achievement, linear growth. Missing data were imputed for the school-level variables using mean imputation procedures in order to

have complete data for analyses using the algorithm HLM3 (Raudenbush, Bryk, Cheong, & Congdon, 2000). Although, missing data can be tolerated at lower levels of analysis in HLM3, complete data are needed at the highest level of analysis, in this case the school level. However, missing data were still present on the science achievement measures for individual students. The time series variable, grade, was centered at grade eight for interpretability. Therefore, average achievement and the instantaneous growth rate at grade eight will be estimated. Additionally, the acceleration or deceleration in growth was estimated from grades 8 to grade 12.

The analysis of the study included three sets of models. All sets of models were conducted for the entire sample. The first set of model is an unconditional growth model. The unconditional growth models were used to examine students' science achievement growth trend. The results, along with theoretical-based decision-making, were used to determine potential predictors of science achievement growth. Finally, conditional models of growth were formulated using the variables determined in the second model. The relationships of these variables to linear growth were tested with the three-level growth models.

*Descriptions of Subjects*

Some potential base year eighth grade sample was excluded in NELS: 88 for mental disability, physical disability or language barrier; in the first follow-up, a special study of base year ineligible students was initiated (Ingels, 1993). From the database analysis, it was found that there were 2447 students who were in Survey 1990 but not in Survey 1988.

The sample for this study was comprised of the 15825 students who were 8th graders in 1988, sophomores in 1990, and seniors in 1992; among them 2653 were defined NNES students. The data were used to construct a comprehensive set of individual-level and school-level variables to measure their effects on NNES students. NELS: 88 employed a two-stage, stratified random probability sample design to obtain its sample. The sampling NNES students' strata were comprised of schools by type of governance or control: public (81.6%), and non-public (9.1%). Sixty-seven percent of the sample students' SES is below zero. Forty-four percent of the students are White (non-Hispanic), 24.3% are Hispanic students, 9.1% are Black (non-Hispanic), 10.1% are Asian or Pacific Islander, and 1.8% are American Indian. Seventy-eight percent of these students' parents had never attended college. Among the NNES students, 20.9% of these students' families usually speak Spanish at home. Seventy-two percent of Hispanic NNES students' families usually speak Spanish at home; 15.6% of Hispanic NNES students' families usually speak English at home. Twenty-one percent of Asian NNES students' families usually speak Chinese at home; 17.8% of Asian NNES students' families usually speak Filipino Language at home; and 11.9% of Asian NNES students' families usually speak Korea at home.

The weighting of responses required a very elaborate, complex design and is explained in comprehensive detail in the first follow-up users' manual (NCES, 1992). What follows is a much abbreviated description of the weighting procedure.

The survey data were weighted to compensate for unequal probabilities of selection and to adjust for the effects of non-response. Weights were calculated in two main steps. First, each case selected was assigned a base year design weight based on the subject's probability of selection into the sample. The weight reflected both the probability of selecting the school and the probability of selecting the student within the school during the base year. This design weight, unadjusted for student response, was then multiplied by the inverse of the case's probability of selection for the first follow-up. Second, the design weights were adjusted for non-response using a technique referred to as multi-dimensional raking. Here weighted response rates were computed separately within cells or subgroups. The weight was applied to cases selected for inclusion in the base year and the first and second follow-ups. Use of this weight permits making unbiased projections to all NNES students (NCES, 1992).

As discussed in Chapter 2, NNES students were not a homogenous group (Lacelle-Peterson & Rivera, 1994). We must recognize this diversity. However, in this study, all NNES students were seen as a group and NES students as the other group. A comparison of the modeling results was compared and contrasted. It was hypothesized that the variability in achievement among NNES students can be explained from the interrelationship of the composite variables examined. The data were used to construct a set of student-level and school-level variables to measure their effects on student science achievement. Dependent variables were 1988, 1990, and 1992 IRT-scaled academic science achievement measures. Independent variables included measures of the individual, school, and family backgrounds (See Appendix A). Individual background included SES, race, gender, number of hours spent on homework; school background included cultural and linguistic diversity in school, science instructional emphasis, school control, and number of parent-staff meetings this year; Family background included parents' highest education level, literacy materials at home, TV watching habits, and language speaking at home.

# CHAPTER FOUR

# RESULTS

This chapter describes the findings from this study and includes the following sections: (1) characteristics of the sample; (2) results from the descriptive and exploratory statistics analysis; (3) hierarchical modeling results; and (4) summary of research question results.

## *Characteristics of the Sample*

As mentioned in the methodology chapter, the sample from this study was drawn from the National Educational Longitudinal Study of 1988 (NELS: 88). The sample contained students who participated in the first three waves of data, collected when students were in the eighth, tenth, and twelfth grades. In the base year of NELS: 88 (eighth grade), schools were the primary sampling units, and students were the secondary sampling units. This sampling resulted in the participation of 24,599 randomly selected students from the selected schools. The sample was freshened in the tenth and twelfth grades in order to make it more representative of students at that particular grade in the year the survey was administered.

One of the advantages of multilevel analysis of longitudinal data is its ability to handle missing data (Bryk & Raudenbush, 1992; Snijders, 1996). Hox (2000, 2002) states that this advantage refers to the ability to handle models with varying time points. Complete data for repeated measurements are not necessary to estimate linear growth. Multilevel regression models do not assume equal numbers of observations, or even fixed time points. Accordingly, respondents with missing observations pose no special problems for this study, and cases with missing points remained in the analysis (Hox, 2002). To get an accurate school-level variables' estimation, only students who had a valid school ID were considered for the study. Missing data can be tolerated at lower levels of analysis in HLM3, although complete data are needed at the highest level of analysis, which was the school level in this study. The sample for this study included *N*= 15,825 sample students nested in 1,468 schools. Of these students, 2,653 students were NNES students, and 13,172 students were NES students. Missing values of the independent variables were replaced by serial means. Appendix B summarizes the characteristics of the student sample based on the variables included in the study.

*Descriptive and Exploratory Data Analysis*

An exploratory *t* test of differences between NNES and NES students' group means was conducted to examine whether NNES students differ significantly from NES students in the characteristics described by selected independent variables. Table 4.1 showed the results of the t-tests for differences between the means of all independent variables for the NNES and NES students.

The results of the *t*-test for differences between the means of all independent variables for the NNES and NES students showed that NNES students in the sample were statistically significant from the NES students for all independent variables, except for "Composite SEX," "Race (Black)," and "Time Spent on Science Homework each week." This means there were no statistically significant differences between the NNES students and the NES students with respect to gender, number of Black students, or different amounts of time spent on science homework each week.

*Table 4.1: Results of the t-test for the Differences Between the Means of All Independent Variables for the NNES and NES Students*

| Independent Variables | Levene's test for equality of variances | | *t*-test for equality of means | | | |
|---|---|---|---|---|---|---|
| | *F* | sig. | *t* | *df* | sig. (2-tailed) | mean difference |
| # of Certified Bilingual or ESL teachers | 637.127 | .000 | 19.260 | 15825 | .000 | .724 |
| # of Hours Watch TV on Weekdays (10th) | 95.923 | .000 | 5.603 | 15825 | .000 | .032 |
| # of Hours Watch TV on Weekdays (12th) | 18.995 | .000 | 3.340 | 15825 | .001 | .018 |
| # of Hours Watch TV on Weekdays (8th) | 21.512 | .000 | 3.677 | 15825 | .000 | .024 |
| # of Hours Watch TV on Weekends (12th) | 2.749 | .097 | 2.324 | 15825 | .020 | .020 |
| # of Hours Watch TV on Weekends (10th) | 38.931 | .000 | 3.207 | 15825 | ..001 | .030 |
| # of Hours Watch TV on Weekends (8th) | 19.565 | .000 | 2.280 | 15825 | .023 | .020 |
| # of Language Minority students in AP courses | 238.176 | .000 | 12.300 | 15825 | .000 | 4.847 |
| # of Parents Staff Meet | 26.105 | .000 | 6.816 | 15825 | .000 | 40.366 |
| # of Students in ESL (8th) | 1641.638 | .000 | -20.488 | 15825 | .000 | -.073 |
| # of Teachers assigned to ESL class | 368.995 | .000 | 15.588 | 15825 | .000 | .814 |
| # of teachers teaching NNES, ESL | 371.615 | .000 | 18.756 | 15825 | .000 | .931 |
| % of LEP(8th) | 2239.632 | .000 | -25.474 | 15825 | .000 | -.148 |
| % of LEP students (10th) | 799.848 | .000 | 23.061 | 15825 | .000 | .506 |
| % of LEP students (12th) | 188.734 | .000 | 18.213 | 15825 | .000 | .3497 |
| % of Students in ESL (10th) | 629.005 | .000 | -14.599 | 15825 | .000 | -.060 |
| % of Students in ESL (12th) | 1823.468 | .000 | -24.131 | 15825 | .000 | -.126 |
| Composite SEX | .029 | .865 | 1.682 | 15825 | .093 | .018 |
| Emphasis on Learning Science Facts/ Rules | 89.964 | .000 | -3.457 | 15825 | .001 | -.034 |
| English Taught to NNES students (8th) | 603.920 | .000 | 23.807 | 15825 | .000 | .231 |
| Ever been in an ESL program | 139409.689 | .000 | 151.695 | 15825 | .000 | .635 |
| Ever in a Language Assistance Program | 10839.463 | .000 | 44.982 | 15825 | .000 | .146 |
| Family has more than 50 Books (10th) | 453.079 | .000 | -11.529 | 15825 | .000 | -.071 |
| Family has more than 50 Books (12th) | 452.131 | .000 | -11.538 | 15825 | .000 | -.071 |
| Family has more than 50 Books (8th) | 454.687 | .000 | -11.517 | 15825 | .000 | -.071 |
| Language Spoken in Student's Home | 982.904 | .000 | -20.843 | 15825 | .000 | -.099 |
| Parents Contacted about Academic Performance | 8.751 | .003 | 3.643 | 15825 | .000 | .037 |
| Parents' Highest Education Level | 1076.337 | .000 | -13.329 | 15825 | .000 | -.131 |
| Race (American Indian) | 132.729 | .000 | 5.815 | 15825 | .000 | .0119 |
| Race (Asian) | 433.375 | .000 | 10.799 | 15825 | .000 | .0548 |
| Race (Black) | 2.413 | .120 | .855 | 15825 | .393 | .0054 |
| Race (Hispanic) | 2193.850 | .000 | 26.496 | 15825 | .000 | .1776 |

| | | | | | | |
|---|---|---|---|---|---|---|
| Race (White) | 912.497 | .000 | -26.636 | 15825 | .000 | -.2496 |
| School Control Composite | 662.372 | .000 | 11.559 | 15825 | .000 | .094 |
| Science Taught in non-English Language | 53799.792 | .000 | 71.525 | 15825 | .000 | .279 |
| SES Composite | 3.460 | .063 | -22.978 | 15825 | .000 | -.38054 |
| Time Spent on Science Homework each week (8th) | 38.366 | .000 | 1.317 | 15825 | .188 | .013 |
| Time Spent on Science Homework in school each week (10th) | 3.894 | .048 | .063 | 15825 | .950 | .001 |
| Time Spent on Science Homework out of School each week ($12^{th}$) | 8.207 | .004 | 1.37 | 15825 | .170 | .010 |
| Time Spent on Science Homework in School each week (12th) | 14.681 | .000 | -.329 | 15825 | .742 | -.003 |
| Time Spent on Science Homework out of School each week (12th) | 9.350 | .002 | .130 | 15825 | .896 | .001 |

Table 4.2 provides the descriptive statistics for the dependent variable of science achievement. None of the dependent variables were recoded. The mean achievements of NES students are all higher than the mean achievement of NNES students across all years.

*Table 4.2a: Science Achievement for the NNES Students in the Sample at Each Grade Level*

| Grade | Mean | *SD* | Minimum | Maximum |
|---|---|---|---|---|
| Eighth | 42.5296 | 8.89250 | 22.68 | 66.25 |
| Tenth | 45.9108 | 9.66909 | 25.87 | 74.92 |
| Twelfth | 49.6301 | 10.14162 | 25.54 | 79.41 |

*Table 4.2b: Science Achievement for NES Students at Each Grade Level*

| Grade | Mean | *SD* | Minimum | Maximum |
|---|---|---|---|---|
| Eighth | 44.7153 | 8.78016 | 22.31 | 69.42 |
| Tenth | 49.7564 | 10.44038 | 25.37 | 74.92 |
| Twelfth | 53.0997 | 10.77732 | 25.29 | 80.41 |

An exploratory *t* test of science achievement differences between NNES and NES students' group means was conducted to determine whether there was a statistically significant difference between the two groups' test results across years. Table 4.3 provides the *t*-test results for the dependent variable of science achievement. The mean achievement scores of NES students are all higher than those of NNES students across years. Both of the means increase linearly in each growth rate over time.

Table 4.3: *Results of the t-test for the Differences Between the Means of Dependent Variables for the NNES and NES Students*

| | Levene's Test for Equality of Variances | | *t*-test for Equality of Means | | | |
|---|---|---|---|---|---|---|
| | *F* | Sig. | *t* | *df* | Sig. (2-tailed) | Mean Difference |
| Eighth | 16.433 | .000 | -22.804 | 13590 | .000 | -4.0035 |
| Tenth | 25.162 | .000 | -24.459 | 10215 | .000 | -5.0848 |
| Twelfth | 2.741 | .098 | -20.454 | 8174 | .000 | -5.0210 |

As a national representative data set, NELS: 88 came with sample weights. Such weights are created to reflect the inverse of probability that a subject gets selected into the sample. If everyone has an equal chance of being included in the sample, weight is not needed. In order to compensate for unequal probabilities of selection and to adjust for the effects of nonresponse and oversampling, appropriate weights were used in all analyses in the current study based on the NELS: 88 user guidelines. More specifically, because only sample members with data in all three waves were usable for this study, the panel weight variable for the longitudinal panel of 1988 to 1992, F2PNLWT, is the appropriate weight to be used. This weight was normed by dividing it by the sample mean to both adjust the data for nonresponse bias and to redistribute the sample so that it corrects for exaggerated sample sizes that would affect significance tests due to weighting of the data.

*Results from the Hierarchical Linear Modeling Analyses*

The purpose of this study was to describe and analyze the development of NNES students' science achievement over a four-year period using individual growth modeling from a hierarchical linear modeling perspective. Socioeconomic, parental, studying habits and school experience factors that may possibly impact growth in students' science achievement were considered. To meet this objective, a series of hierarchical linear models were built using HLM 6.0. As mentioned earlier, missing values on any covariates were inputted using serial means.

The missing values of the dependent variable of science achievement were not deleted or imputed because multilevel modeling does make use of any values that it can to estimate parameters. Observations with achievement levels at two time points may still provide information in building models.

*Analysis: Step 1*

The first step in the analysis involved estimating the unconditional model without any student-level or school-level predictor variables in order to provide estimates of average school outcomes and the variability in these outcomes among schools. The linear growth model is used to model specifications of growth trajectories.

The linear growth model is provided below. For the *j*th school, the model consists of a within-individual level and a between-individual level. We begin with a within-individual level model of students' science achievement development at time *t* of individual *i* in school *j*:

$$Y_{tij} = \pi_{0ij} + \pi_{1ij} a_{tij} + e_{tij} \qquad (1)$$

where, $Y_{itj}$ is the outcome of science achievement for individual *i* in school *j* at time *t*; $\pi_{0ij}$ represents the status for individual *i* in school *j* at $a_{tij}= 0$ ($a_{tij}$ denotes the scaling variable representing the age at time *t* for individual *i* in school *j*). And, $\pi_{1ij}$ represents the growth trajectory for individual *i* in school *j* over the time; $e_{tij}$ is the residual term assumed to be normally and independently distributed with mean 0 and variance $\sigma^2_{tij}$. Thus, the linear model has an expected initial status factor and one growth rate factor for the overall growth trajectory. The specific meaning of $\pi_{0ij}$ depends on the scaling of the grade metric. Table 4.4 shows the coding scheme for the linear growth model.

*Table 4.4: Coding Scheme for the Linear Growth Model*

| | Grade | | | Interpretation of π s: |
|---|---|---|---|---|
| | Eighth | Tenth | Twelfth | |
| *a* | 0 | 1 | 2 | $\pi_1$ growth rate |
| | | | | $\pi_0$ status for 8th grade |

Using the coding scheme, the predicted science achievement level at each grade would be determined by the following:

Grade Eighth $=\pi_0$

Grade Tenth $=\pi_0 + \pi_1$

Grade Twelfth $=\pi_0 + \pi_1 + \pi_1$ (2)

*Table 4.5: HLM Unconditional Growth Model Parameter Estimates*

| | Unconditional Linear Growth Model |
|---|---|
| **Fixed Effects** | ----- |
| *Model for initial status* ($\pi_{0ij}$) | ----- |
| Intercept ($\beta_{000}$) | 45.29** |
| *Model for growth rate* ($\pi_{1ij}$) | ----- |
| Intercept ($\beta_{100}$) | 3.63** |
| **Random Effects** | ----- |
| Level-1 effect (Reported as sigma squared on HLM output) | 22.62 |
| Level-2 and Level-3 effects | ----- |
| Intercept, $r_{0ij}$ (Tau intercept ) | 16.71 |
| Slope, $r_{1ij}$ (Tau Time) | 1.18 |
| **Deviance (# of parameters)** | 32607.38 (9) |

* = estimates significance at .05, ** = estimates significance at .01

Table 4.5 shows the unconditional model fitting statistics for sample students. The coefficients for sample students (denoted by *g* for linear growth) were both positive ($\gamma_{000}$ = 45.29, $\gamma_{100}$=3.63). As we mentioned in the coding scheme section, the growth rate is $\pi_1$, and the growth parameter for sample students from eighth grade to twelve grade is 3.63. The above result of the unconditional model indicated that sampled students' science achievement increased as they progressed in grade level.

*Analysis: Step 2*

Student-level variables are added to the Level-2 model. Both the Level-2 and Level 3 variables in this study were grand-mean centered. The NNES student sample and NES student sample were very different in sample size, and NNES students were sparsely distributed in many schools. It would not be appropriate to estimate the NNES students' model and the NES students' model separately. As the NNES condition was dichotomy, the whole students sample and the NNES variable interaction were used to test for different effects (Palardy, 2008) between NNES and NES populations.

NNES students were coded 0 and NES students were coded 1 under the student-level variable *NES*. Interactions between student level predictors *X* and *NES* were calculated from these main effects, given by the equation *NX=NES*X*. For example, the formula *NBYSES=NES*BYSES* was used to test whether the relationship between science achievement and the composite SES variable differs for NNES and NES students. When these interactions were added to the model, if the interaction coefficient was statistically non-significant, it meant that NES students did not have any significant difference in the tested independent variable regarding their science achievements.

There would be more than one explanatory variable at this level. Assume that we had *P* explanatory variable *X* at Level-2, indicated by the subscript *p* (*p*=1…*P*). Likewise, we had *Q* explanatory variable *NX* at Level-2, indicated by the subscript *q* (*q*=1…Q).

Level-2 model:

$$\pi_{0ij}=\beta_{00j}+\beta_{0pj}\,X_{pij}+\beta_{0(p+q)j}\,(NX_{qij})+\beta_{0(p+q+1)j}\,(NES)+r_{0ij}$$

$$\pi_{1ij}=\beta_{10j}+\beta_{1pj}\,X_{pij}+\beta_{1(p+q)j}\,(NX_{qij})+\beta_{1(p+q+1)j}\,(NES)+r_{1ij} \qquad (3)$$

In the Level-2 model, $\beta_{0pj}$ and $\beta_{1pj}$ were the estimated effects of the student-level predictors of initial achievement and growth rates, respectively, within each school. Again, $NX_{qij}$ represented the interaction variable (*NES*)*($X_{qij}$).

As NES was coded 0 for NNES students, 1 for NES students, the actual Level-2 models for NNES students and NES students would be respectively by the equations below.

Level-2 model for NNES students (*NES*=0):

$$\pi_{0ij}=\beta_{00j}+\beta_{0pj}X_{pij}+r_{0ij}$$

$$\pi_{1ij}=\beta_{10j}+\beta_{1pj}X_{pij}+r_{0ij} \qquad (4)$$

Level-2 model for NES students (*NES*=1):

$$\pi_{0ij}=\beta_{00j}+\beta_{0pj}X_{pij}+\beta_{0(p+q)j}X_{qij}+\beta_{0(p+q+1)j}+r_{0ij}$$

$$\pi_{1ij}=\beta_{10j}+\beta_{1pj}X_{pij}+\beta_{1(p+q)j}X_{qij}+\beta_{1(p+q+1)j}+r_{1ij} \qquad (5)$$

The model building strategy advised by Raudenbush and Bryk (2002) is to add a single variable at a time to both level-2 models, retaining it if it is significant or removing it if it is not significant. Twenty-two variables were added to intercept, slope at level 2. Of these, 12 were shown to be statistically significant and retained. Table 4.6 shows the final results of the Level-2 model.

The expected level of science achievement for the initial status NNES students (all of the independent variables equaled to zero, that meant, SES=0, referenced ethnicity group and etc.) was 45.47. The expected difference in initial science achievement of NNES students who were American Indian compared to students who were not American Indian is -3.94 (significant at .01). The science achievement of Black NNES students was 3.63 lower than that of NNES.

*Table 4.6: Predictors of NNES students' Science Achievement Growth from Student-level Variables*

| Variable | Intercept | | Slope | |
|---|---|---|---|---|
| | coefficient | *SE* | coefficient | *SE* |
| Intercept | 45.47** | 0.08 | 3.69** | 0.41 |
| Race (American Indian) | -3.94** | 0.57 | ----- | ----- |
| Race (Black) | -3.63** | 0.22 | -1.11** | 0.11 |
| Composite sex | 1.38** | 0.11 | 0.88** | 0.07 |
| Race(Hispanic) | -2.44** | 0.21 | -0.42** | 0.11 |
| SES Composite | 2.53** | 0.11 | 0.45** | 0.06 |
| Parents' Highest Education Level | 1.14** | 0.17 | 0.33** | 0.10 |
| # of Hours Watch TV on Weekdays (8th) | -0.70** | 0.19 | ----- | ----- |
| Family has more than 50 Books (8th) | 4.99** | 0.61 | ----- | ----- |
| Language Spoken in Student's Home | 1.04** | 0.26 | ----- | ----- |
| Ever in a Language Assistance Program | -1.12** | 0.40 | ----- | ----- |
| Time Spent on Science Homework each week (8th) | -0.69** | 0.12 | ----- | ----- |
| Ever been in an ESL program | -3.46** | 0.36 | 0.32** | 0.08 |
| # of Hours Watch TV on Weekdays (10th) | -1.85** | 0.22 | ----- | ----- |
| # of Hours Watch TV on Weekdays (12th) | -1.50** | 0.22 | -0.26** | 0.12 |
| Family has more than 50 Books (12th) | 6.44** | 0.59 | 0.38** | 0.12 |

* = significant at α = .05; ** = significant at α = .01; report all values to 2 decimal places

students who were not Black in initial. The Hispanic NNES students' science achievement was 2.44 lower than that of NNES students who were not Hispanic in initial. Male NNES students' science achievement was 1.38 higher than that of female NNES students. SES was statistically and positively related to NNES students' science achievement in initial. NNES students whose parents' highest education was college and up had 1.14 higher science achievements than NNES students whose parents' highest education was not up to college. NNES students who watched television more than five hours per day on weekdays at the eighth grade level had 0.70 lower science achievement than did NNES students who watched less TV. NNES students whose families had more than 50 books at the twelfth grade level had a science achievement score 6.44 higher than that of NNES students whose families had fewer than 50 books. NNES students who spoke English at home had science achievement score 1.04 higher than NNES students who did not speak English at home. NNES students who had ever been in a language assistance program had a science achievement score that was 1.12 lower than that of NNES students who had not been in these type of program. NNES students who spent less than 1 hour on science homework each week at the eight grade level had a science achievement score 0.69 lower than that of NNES students who spent more time on science homework. NNES students who had ever been in an ESL program had a science achievement score 3.46 lower than that of NNES students who had never been in ESL programs. NNES students who watched TV more than five hours a day on weekdays at the tenth grade level had a science achievement score 1.85 lower than that of students who watched TV less than five hours a day. Students who watched TV more than five hours a day on weekdays at the twelfth grade level had a science achievement score 1.50 lower than that of students who watched TV less than five hours a day.

The expected growth rate in science achievement for an NNES student who was not Hispanic or Black, whose parents' highest education level was less than college, who was never in an ESL program, SES=0, female, who did not watch TV more than five hours a day on weekdays, and whose family had fewer than 50 books was 3.69. The expected difference in growth rate in science achievement of NNES students who were Hispanic compared with NNES students who were not Hispanic was -0.42. NNES students who were Black had a 1.11 flatter growth rate than NNES students who were not Black. Male NNES students had a 0.88 steeper growth rate than female NNES students. SES was statistically and positively related to growth rate. NNES students whose parents' highest education level was college and up, tended to have a 0.33 steeper growth rate than other NNES students whose parents' highest education level was less than college. NNES students who had ever been in an ESL program had a 0.32 steeper growth rate than did students who had never been in an ESL program. NNES students whose families had more than 50 books at the 12th grade level had a 0.38 steeper growth rate than did

NNES students whose families had fewer than 50 books. Scores for NNES students who watched TV more than five hours a day on weekdays were 0.26 flatter than scores for students who watched TV less than five hours a day on weekdays.

The variables that statistically significantly predicted NNES students' science achievement and its growth included Race (American Indian), Race (Black), Race (Hispanic), Composite SEX, SES Composite, Parents' Highest Education Level, # of Hours Watching TV on Weekdays (8th), Family has more than 50 Books (8th), Language Spoken in Student's Home, Ever in a Language Assistance Program, Time Spent on Science Homework each week (8th), Ever been in an ESL program, # of Hours Watching TV on Weekdays (10th), # of Hours Watching TV on Weekdays (12th), and Family has more than 50 Books (12th). The variables that statistically significantly predicted acceleration in NNES students' science achievement included Race (Black), composite SEX, Race (Hispanic), SES Composite, Parents' Highest Education Level, Ever been in an ESL program, # of Hours Watch TV on Weekdays (12th), and Family has more than 50 Books (12th). The other 10 independent variables that were tested did not significantly affect NNES students' science achievement.

In contrast, the 10 variables that statistically significantly predicted NES students' science achievement and its growth were Race (American Indian), Race (Black), Race (Hispanic), composite SEX, SES composite, Parents' Highest Education Level, # of Hours Watch TV on Weekdays (8th), Family has more than 50 Books (8th), Language Spoken in Student's Home, Time Spent on Science Homework each week (8th), Time Spent on Science Homework in school (12th), Time Spent on Science Homework out of school (12th), # of Hours Watch TV on weekends (8th), # of Hours Watch TV on Weekdays (10th), # of Hours Watch TV on Weekdays (12th), Family has more than 50 Books (12th). A detailed final estimate of whether these effects differ for NES students compared with NNES students will be given in the summary section of this chapter.

*Analysis: Step 3*

The variables retained from Step 2 of the analysis were used to model science achievement growth and acceleration/deceleration in growth in a three-level hierarchical model. There was more than one explanatory variable at this level. Assume that we had $Z$ explanatory variable $W$ at Level 3, indicated by the subscript $z$ ($z$=1…$Z$).

Level 3 model: $\beta_{00j}=\gamma_{000}+\gamma_{00z}W_{zj}+\mu_{00j}$

$$\beta_{0pj}=\gamma_{0p0}+\gamma_{0pz}W_{zj}$$

$$\boxed{\beta_{0(p+q)j}=\gamma_{0(p+q)0}+\gamma_{0(p+q)z}W_{zj}}$$

$$\boxed{\beta_{0(p+q+1)j}=\gamma_{0(p+q+1)0}+\gamma_{0(p+q+1)z}W_{zj}+\mu_{0(p+q+1)j}}$$

$$\beta_{10j}=\gamma_{100}+\gamma_{10z}W_{zj}+\mu_{10j}$$

$$\beta_{1pj}=\gamma_{1p0}+\gamma_{1pz}W_{zj}$$

$$\boxed{\beta_{1(p+q)j}=\gamma_{1(p+q)0}+\gamma_{0(p+q)z}W_{zj}}$$

$$\boxed{\beta_{1(p+q+1)j}=\gamma_{0(p+q+1)0}+\gamma_{0(p+q+1)z}W_{zj}+\mu_{1(p+q+1)j}} \qquad (6)$$

Within each school, $\gamma_{00z}$ and $\gamma_{10z}$ are the estimated effects of the school-level variables on the mean initial test scores and test score growth, respectively. Except for the random effects for *NES* ($\mu_{(p+q+1)j}$), in the remaining equations, the intercept terms were "fixed" ($\mu_{(p+q)j}$= 0), so the effect of the within-school predictors was constrained to be the same for all schools (Raudenbush & Bryk, 2002). Equations surrounded by borders above were the Level 3 models for NNES students. Equations without borders were used to test whether NES students had significantly difference from NNES students in the tested school-level variable about their science achievement.

As presented in Table 4.7, there were several statistically significant predictors of average school achievement and growth. School-level variables that statistically significantly predicted the average school achievement of NNES students were School Control Composite, % of LEP(8th), # of teachers teaching LEP or ESL, English Taught to NNES students (8th), # of Students in ESL (8th), Science Taught in non-English Language, % of LEP students (10th), # of Teachers assigned to ESL class, # of Language Minority students in AP courses, # of Parents Staff Meet, % of LEP students (12th), % of Students in ESL (12th).

NNES students in public schools had a predicted average science achievement score 0.62 lower than that of NNES students in nonpublic schools. NNES students in schools that had less than 10% percent of LEP students (8th) had predicted average science achievement score that were 1.91 higher. NNES students in schools that taught English to NNES students had a predicted average science achievement score that was 0.66 lower. NNES students in schools that taught science in a non-English language had a predicted average science achievement score that was 2.17 lower. NNES students in schools that had more parents met by staff had lower predicted average science achievements. NNES students in schools that had less than 10% percent of LEP students (12th) had a predicted average science achievement score that was 0.53 lower. NNES students in schools that emphasized learning science facts and rules had a predicted average science achievement score that was 1.07 higher.

American Indian NNES students in schools that had science taught in a non-English language had a predicted average science achievement score that was 3.98 lower than American Indian NNES students in schools that only had science taught in English. Hispanic

NNES students in schools that had less than 10% of LEP students (8th) showed a predicted average science achievement score that was 1.93 lower.

*Table 4.7: Predictors of NNES Students' Science Achievement Growth from School-level Variables*

| school variables | intercept coefficients | slope coefficients |
|---|---|---|
| School Control Composite | -0.62 *(intercept), -6.00** (Ever been in an ESL program), 1.54* (Language Spoken in Student's Home), -6.38** (Ever in a Language Assistance Program), | -0.38** (intercept) |
| % of LEP(8th) | 1.91**(intercept), -1.93**[Race (Hispanic)], -2.09** (# of Hours Watch TV on Weekdays (12th)), -2.38** [# of Hours Watch TV on Weekdays (8th) ], 0.88* (SES Composite) | ----- |
| # of teachers teaching LEP, ESL | -0.20** [# of Hours Watch TV on Weekdays (8th) ] | ----- |
| English Taught to NNES students (8th) | -0.66** (intercept), 6.27** (Ever been in an ESL program), 6.60** (Ever in a Language Assistance Program), -1.09*[NES *Time Spent on Science Homework out of School each week (12th)] | ----- |
| Parents Contacted about Academic Performance | ----- | -0.81** (intercept) |
| # of Students in ESL (8th) | -2.80* (Ever been in an ESL program), 3.67** (Language Spoken in Student's Home), 6.99** (English Taught to NNES students (8th)) | 3.03** (Parents' Highest Education Level), -1.28** (SES Composite) |
| Science Taught in non-English Language | -2.17** (intercept), -3.98* (Race (American Indian)), -2.39** [Family has more than 50 Books (8th) ] | 0.89* [Family has more than 50 Books (12th)] |
| % of LEP students (10th) | -0.29** (SES Composite), -0.47** (bys79) | ----- |
| # of Teachers assigned to ESL class | 0.28** (Ever in a Language Assistance Program) | ----- |
| # of Certified Bilingual or ESL teachers | ----- | ----- |
| # of Language Minority students in AP courses | -0.01* (Ever in a Language Assistance Program) | ----- |
| # of Parents Staff Meet | -0.01** (intercept), 0.01** (bys79) | ----- |
| Emphasis on Learning Science Facts/ Rules | 1.07* (intercept) | -1.15* (Parents' Highest Education Level) |
| % of LEP students (12th) | -0.53** (intercept) | ----- |
| % of Students in ESL (12th) | -1.56*(Parents' Highest Education Level), -1.34*[Time Spent on Science Homework each week (8th) ] | -1.16*[# of Hours Watch TV on Weekdays (12th) ] |

* = estimates significance at .05, ** = estimates significance at .01

NNES students who had ever been in an ESL program and who were in schools that had less than 10% percent of students in ESL tended to have predicted average science achievements scores that were 2.80 lower than the same NNES students whose schools had more than 10% percent of students in ESL. NNES students who had ever been in an ESL program and who were in schools that had 8th grade English taught to NNES students had predicted average science achievement scores that were 6.27 higher than the same kind of NNES students whose schools did not have 8th grade English taught to NNES students. NNES students who had ever been in an ESL program and who were in public schools tended have predicted average science achievement scores that were 6.00 lower that those of the same kind of NNES students in nonpublic schools.

NNES students watching more than 5 hours of television a day on weekdays in schools that had less than 10% of LEP students tended to have predicted average science achievement scores that were 2.09 lower than the same kinds of NNES students in schools that had more than 10% of LEP students. NNES students who had parents whose highest education was college and up and who were in schools that had less than 10% percent of student in ESL tended to have predicted average science achievement scores that were 1.56 lower than the same kinds of NNES students in schools that had more than 10% of LEP students.

NNES students speaking English at home who were in schools that had less than 10% of students in ESL tended to have predicted average science achievement scores that were 3.67 higher than the same kinds of NNES students in schools that had more than 10% of students in ESL. NNES students speaking English at home who were in public schools tended to have predicted average science achievement scores that were 1.54 higher than the same kinds of NNES students in nonpublic schools.

NNES students watching TV more than 5 hours a day on weekdays who were in schools that had less than 10% of LEP students tended to have a score that was 2.38 lower than the same kinds of NNES students in schools that had more than 10% of LEP students. NNES students watching TV more than 5 hours a day on weekdays who were in schools that had more teachers teaching NNES or ESL tended to have lower predicted average science achievement scores.

NNES students who had been in a language assistance program and who were in schools that had 8th grade English taught to NNES students tended to have predicted average science achievement scores that were 6.60 higher. NNES students who had been in a language assistance program and who were in schools that had more teachers assigned to ESL classes tended to have higher predicted average science achievements. NNES students who had been in a language assistance program in schools that had more language "minority" students in AP courses tended to have lower predicted average science achievements. NNES students who had been in a language assistance program and who were in public schools tended to have a predicted average science achievement scores that were 6.38 lower.

NNES students with a family having more than 50 books and who were in schools that taught science in a non-English language tended to have predicted average science achievement scores that were 2.38 lower. NNES students with a higher SES composite who were in schools that had less than 10% LEP students tended to have a higher predicted average science achievement scores.

NNES students spending less than one hour on science homework each week and who were in schools that had more parents met by the staff tended to have higher predicted average science achievement scores. NNES students spending less than one hour on science homework each week and who were in schools that had less than 10% percent of LEP students tended to have predicted average science achievements that were 0.47 lower. NNES students spending less than one hour on science homework each week and who were in schools that had less than 10% percent of ESL students tended to have predicted average science achievement scores than were 1.34 lower.

School-level variables that statistically significantly predicted the average school growth rate of NNES students were School Control Composite, Parents Contacted about Academic Performance, # of Students in ESL (8th), Science Taught in non-English Language, % of LEP students (10th), Emphasis on Learning Science Facts/ Rules, % of LEP students (12th), and % of Students in ESL (12th).

NNES student in schools that did not contact parents about academic performance had an average growth rate 0.80 lower than did NNES students in schools that contacted parents about academic performance. NNES students in public schools had average growth rates that were 0.39 lower than those of NNES students in non-public schools.

NNES students with families having more than 50 books in schools that taught science in a non-English language tended to have an average growth rate that was 0.89 higher than that of NNES students with families having more than 50 books in schools that taught science only in English. NNES students watching TV more than 5 hours a day on weekdays who were in schools that had less than 10% students in ESL tended to have average growth rates that were 1.16 lower than NNES students watching TV more than 5 hours a day on weekdays and who were in schools that had more than 10% students in ESL. NNES students with a higher SES and who were in schools that had less than 10% students in ESL tended to have a lower average growth rate.

NNES students with parents whose highest education level was college and up and who were in schools that had less than 10% of students in ESL tended to have an average growth rates that was 3.03 higher than that of the same kinds of NNES students in schools that had more than 10% of students in ESL. NNES students with parents whose highest education level was college and up and who were in schools that had emphasis on science facts and rules tended to have average growth rates that were 1.16 lower.

Adding the school policy and practice variables accounted for a significant amount of the unexplained variance in science achievement and growth beyond that explained by the student variables, increment in chi-square = 414.25 *df* =44, $p < 0.001$. A summary of the models tested in this study is displayed in Table 4.8.

*Table 4.8: Comparisons of Models for Sample Students*

| | Unconditional | Level-2 | Final |
|---|---|---|---|
| Deviance | 322607.38 | 318220.92 | 317806.67 |
| # of Parameters | 9 | 47 | 91 |
| Level-1 effect variance | 22.62 | 22.70 | 22.69 |
| Level-2 effects variance intercept | 16.70 | 5.23 | 4.43 |
| Level-2 effects variance slope | 1.17 | 0.71 | 0.68 |
| Intra-class Correlations | 0.42 | 0.19 | 0.16 |
| % of variance in $r_{0ij}$ explained | ----- | 69% | 73% |
| % of variance in $r_{1ij}$ explained | ----- | 39% | 42% |

*Summary of Research Questions Results*

(1) Research Question 1: Has the NNES students' science achievement improved during the years? If they did improve, how much improvement occurred?

The NNES students' science achievement increased as students progressed in grade level. The growth parameter in the unconditional model is 3.63>0 ($P<.001$).

(2) Research Question 2: What kinds of learning variables affect NNES students' science achievement and achievement growth?

The student-level variables that statistically significantly predicted NNES students' science achievement and its growth were Race (American Indian), Race (Black), Race (Hispanic), composite SEX, SES composite, Parents' Highest Education Level, # of Hours Watch TV on Weekdays (8th), Family has more than 50 Books (8th), Language Spoken in Student's Home, Ever in a Language Assistance Program, Time Spent on Science Homework each week (8th), Ever been in an ESL program, # of Hours Watch TV on Weekdays (10th), # of Hours Watch TV on Weekdays (12th), and Family has more than 50 Books (12th). The variables that statistically significantly predicted acceleration in NNES students' science achievement were Race (Black), composite SEX, Race (Hispanic), SES Composite, Parents' Highest Education Level, Ever been in an ESL program, # of Hours Watch TV on Weekdays (12th), and Family has more than 50 Books (12th). Refer to table 4.6 for the exact coefficients. The other 10 student-level independent variables that were tested did not significantly affect NNES students' science achievement.

School-level variables that statistically significantly predicted the average school achievement of NNES students and its growth were School Control Composite, % of LEP(8th), # of teachers teaching LEP or ESL, English Taught to NNES students (8th), Parents Contacted about Academic Performance, # of Students in ESL (8th), Science Taught in non-English Language, % of LEP students (10th), # of Teachers assigned to ESL classes, # of Language Minority students in AP courses, # of Parents Staff Meet, Emphasis on Learning Science Facts/ Rules, % of LEP students (12th), and % of Students in ESL (12th). Refer to Table 4.7 for exact coefficients.

In conclusion, there were 15 student-level variables and 14 school-level variables that statistically significantly influenced NNES students' science achievement and its growth.

(3) What variables exert the greatest influence on NNES students' science achievement and achievement growth?

The most significant student-level positive predictors of NNES students' science achievement were family has more than 50 books (6.44) and SES composite (2.53). The most significant student-level negative predictors of NNES students' science achievement were: Race (American Indian, -3.94; Black, -3.63; Hispanic, -2.44) and Ever been in an ESL program (-3.46).

The most significant student-level positive predictors of NNES students' science achievement growth were composite SEX (male 0.88) and SES composite (0.45). The most significant student-level negative predictors of NNES students' science achievement growth were Race (Black, -1.11; Hispanic, -0.42) and Number of hours watch TV on Weekdays (-0.26).

The most significant school-level positive predictors of NNES students' science achievement were % of LEP students (1.91) and Emphasis on Learning Science Facts/ Rule (1.07). The greatest significant school-level negative predictors of NNES students' science achievement were science taught in non-English language (-2.17) and School Control (-0.62). The most significant school-level negative predictors of NNES students' science achievement growth were Schools had not contacted parents about academic performance (-0.81) and School Control (-0.38).

(4) Do the statistically significant factors found differ for NES students?

Table 4.9 shows the whether the effects differ for NES compared with NNES students. In Table 4.9a, student variables that were significant at intercept models are predictors of students' science achievement; student variables that were significant at slope models were predictors of students' science achievement growth. In Table 4.9b, school variables that were significant at slope models were predictors of average school science achievement; school variables that were significant at slope models were predictors of average school science achievement growth.

*Table 4.9a: Student-level Effects Differ for NES Students Compared with NNES Students*

| student variables | Effects differ for NES compared with NNES | |
|---|---|---|
| | significant in intercept | significant in slope |
| Race (Asian) | ----- | 0.29* |
| # of Hours Watch TV on Weekends | -0.43** | -0.15* |
| # of Hours Watch TV on Weekdays (10th) | ----- | -0.27* |
| Time Spent on Science Homework in School each week (12th) | ----- | -0.25** |
| Time Spent on Science Homework out of School each week (12th) | -0.51** | ----- |

*Table 4.9b: School-level Effects Differ for NES Students Compared with NNES Students*

| school variables | Effects differ for NES compared with NNES | |
|---|---|---|
| | significant in intercept | significant in slope |
| School Control Composite | 1.17** [NES*Time Spent on Science Homework out of School each week (12th) ], -7.35(NES) | ----- |
| # of Students in ESL (8th) | -2.09*(NES) | ----- |
| English Taught to NNES students (8th) | -1.09*( [NES*Time Spent on Science Homework out of School each week (12th) ], 6.99**(NES) | ----- |
| % of LEP students (10th) | -0.41* [NES*Time Spent on Science Homework out of School each week (12th) ] | 0.18*(NES) |
| # of Certified Bilingual or ESL teachers | 0.14*(NES) | ----- |
| % of LEP students (12th) | ----- | -0.29*[NES*Race (Asian)] |

There were some differences in factors that affect students' science achievement between the sample of NNES students and the sample of NES students. For student-level variables, Asian students had a statistically significantly better growth rate for the NES students' sample, but it was not a significant factor in the NNES students' sample. Number of hours watching TV on weekends was a statistically significant factor for predicting science achievement and growth rate for the NES students' sample, but it was not a significant factor for the NNES students' sample. Number of hours watching TV on weekdays was a statistically significant factor for predicting NES students' science achievement growth rate for the NES students' sample, but it was not a significant factor for the growth rate in the NNES students' sample. Time Spent on Science Homework out of School was a significant factor for the NES students' sample, but it was not a significant factor for the NNES students' sample.

For school variables, number of Certified Bilingual or ESL teachers was a statistically significant predictor for the NES students' sample, but it was not significant for the NNES students' sample. Schools with a higher number of Certified Bilingual or ESL teachers had a better predicted science achievement for NES students.

# CHAPTER FIVE

# DISCUSSION

The data analyses and model fitting procedures used to study NNES students' science achievement revealed that NNES students in general had lower science achievement than NES students, although NNES students' science achievement did increase continuously from the eighth grade through the twelfth. The background, parental, academic, and school factors had significant impact on initial NNES students' science achievement, and many of the factors considered in this study had significant effects on the rate of change in NNES students' science achievement, as revealed by multilevel modeling. There were 15 student-level variables and 14 school-level variables tested in this study that statistically significantly influenced NNES students' science achievement and its growth.

This study employed a non-experimental design. As a result, the researcher was limited to making best guesses regarding correlations and effects. That is, no definitive claims could be made regarding which variables actually caused another. The only assertion that can be made is that given certain statistical and methodological controls, certain effects may be observed. With this frame of reference in mind, conditional or independent variables related to NNES students' science achievement are presented below and followed by tentative explanations.

## *The Effect of Background Variables on NNES Students' Science Achievement*

As reported in Chapter 4, SES was statistically and positively correlated to NNES students' science achievement and its growth. This seems to suggest the possibility of students' economic impoverishment negatively impacting their achievement and undermining their achievement growth. This finding was to be expected. The socioeconomic status of the families represented a composite variable measured by parents' education, parents' occupation, and family income. Students having higher levels of socioeconomic status often enjoy greater access to learning recourses, which aids in their higher achievement. Again, this does not mean that poor or disadvantaged NNES children cannot learn. There are many factors related. First, some of these students are educated in schools that, on most measures of quality and funding, are woefully inadequate. The families have little or no choice of schools. This is particularly true in economically depressed urban areas, where poor performing schools are just one of several obstacles with which poor people must contend and no wonder whether the schools even pay special attentions to NNES students. Second, some parents of these children are still struggling to survive and have little time to help their children to study or to answer the questions the students meet in their studies. Parents of these students often believe that schools are responsible for their children's education on the whole, while ignoring the effects of family and community environment on their NNES children's achievement. If these students do not achieve well, parents will often assume that the children are not working hard or that the school is not good enough. Third, educational practices often have the effect of favoring privileged students and hindering the educational opportunities of poorer students and underrepresentative students. One example of this is the tracking system mentioned in previous chapters. Linguistic-"minority" students are overrepresented in low-track classrooms (Medina, 1988). They seem to be disproportionately and adversely affected by this system (Harklau, 1994).

Race was another significant background predictor related to NNES students' science achievement and its growth. American Indian, Black, and Hispanic NNES students had lower initial science achievement. Black and Hispanic NNES students had lower expected growth rates in science achievement. Different ethnic groups of NNES students had different average science achievements and achievement growth. NCLB requires that states disaggregate and report the performance of NNES students within difference ethnic groups. Cultural differences in this study were apparent, but for the most part, they had been constructed by society. That is to say, the differences we perceived were largely based on factors such as socioeconomic circumstance, English learning, and attitudes towards science. Language difficulties may be only a part of a much larger chain of causation. It is necessary to examine how NNES students of multicultural populations are being educated.

Gender was statistically significantly related to NNES students' science achievement and its growth. Male NNES students' science achievements were 1.38 higher than female NNES students. Male NNES students had 0.07 steeper growth rates than did female NNES students. Many previous studies had indicated that science was the curricular area that favored boys in the classroom. This also seemed to be the case for NNES students. It is important that teachers become aware of this gender issue and work to make opportunities available for both boys and girls to learn more about science.

From above, we can see the background characteristics (socioeconomic status, race, gender) of students are salient factors predict students' science achievement. However, students of all backgrounds should be provided with challenging learning opportunities to explore scientific phenomena and scientific knowledge. Some students may need more specific guidance, using scientific knowledge and practices to clarify their language and cultural experience. Teachers and curriculum designers need to understand the different needs of students in order to decide how much explicit instruction to provide and to what degree students can accept this instruction.

*Family Influences on NNES Students' Science Achievement*

Family environment was found to have a strong impact on NNES students' science achievement. This study also found that parental factors had a strong impact on students' achievement in the eighth grade and were positively associated with students' achievement at each time point in the study. Programs that help parents understand what will be required of them to help their children improve their achievements would be beneficial. Parents, especially those from lower SES backgrounds, need to be educated on how to best help their children select appropriate courses to take. They also need to develop an awareness of the language assistance programs that are available to their children. Educating parents from lower SES backgrounds and who have had no college education about program choices may help them not only to have higher expectations for their children, but also to play a more active role in their children's education later on.

Parents' education level was a significant factor predicted NNES students' science achievement. NNES students whose parents' highest education was college and up had 1.14 higher science achievements than NNES students whose parents' highest education was not up to college. NNES students whose parents' highest education level was college and up tended to have 0.33 steeper growth rates than other NNES students whose parents' highest education level was less than college. Parents play an important role in their children's learning. In families where social relationship ties are strong, students are more likely to adopt their parents' values, norms, and expectations. If parents from these families emphasize the importance of education, their children are likely to have higher achievement, regardless of other background factors such as race (Khattab, 2002; Schneider & Stevenson, 1999). Aside from being actively involved in their children's education, parents of NNES students can also provide a home environment that can have a positive impact on learning. Parents with higher education levels may better serve as models for learning, determine the educational resources available in the home, and hold more positive attitudes and values towards education. Parents with higher levels of education may be more knowledgeable about standardized testing and of ways to best prepare for these tests. NES students were not significantly different from NNES students with regard to parents' highest education factor.

NNES students whose families had more than 50 books at the twelfth grade time point had 6.44 higher science achievements than did NNES students whose families had less than 50 books. NNES students whose families had more than 50 books at 12th grade had a 0.38 steeper growth rate than did NNES students whose families had less than 50 books. Books were the main educational resources in the homes. Relative to other countries, the United States has a large percentage of students having a high level of educational resources at home. Having more than 50 books at home suggests that a better environment for studying is supported by the family (with the exception of some parents who like to buy books that no one is expected to read). As several studies and reports have shown in recent years, middle and high school students often lack the skills and motivation to decipher the more complex reading materials demanded by upper-grade academic disciplines. Balanced literacy instruction incorporates background information, vocabulary development and strategies for constructing meaning through listening, writing, and speaking, as well as reading (Meltzer & Hamann, 2004). NNES students also need help recognizing the text features and structures of the reading in science content area; NES students can benefit from this type of instruction as well.

Television watching habits were a significant factor for NNES students' science achievement. Students who watched television more than five hours a day on weekdays at the

12th grade level had 1.50 lower science achievements than students who watched television less than five hours a day. The growth rate in achievement of NNES students who watched television more than 5 hours a day on weekdays was 0.12 flatter than with students who watched television less than 5 hours a day on weekdays. As mentioned in Chapter 2, there are several problems that may develop when students spend a great deal of time watching television, other than less time being available for studying. This study confirmed that too much television watching was one of strongest factors negatively affecting NNES students' science achievement. Some NNES students' parents may think television watching is a good way for NNES students to acquire English learning. However, the findings from this study suggest that parents need to carefully monitor the programs that NNES students watch and set limits on the amount of time these students spend watching television.

NNES students who spoke English at home had 1.04 higher science achievements than did NNES students who did not speak English at home. This finding indicates that if NNES students' homes can provide an English speaking environment, it would be beneficial for NNES students' English acquirement and science learning. NNES students' home language and cultural values, acquired in their home and community environment, serves as their framework for constructing new understandings. Learning is mediated by linguistic, cultural, and social factors. Learning is enhanced—indeed, made possible— when it occurs in contexts that are culturally, linguistically, and cognitively meaningful and relevant to students. Home language and cultures are the tools that students use to construct their understandings of the world (Lee, 2005).

### *Student Influences on NNES Students' Science Achievement*

Engagement in a subject is important for learning. The time that NNES students spent on science was an important predictor of their science achievement. NNES students who spent less than one hour on science homework each week at the eighth grade level had 0.69 lower science achievements than did NNES students who spent more time on science homework. Many researchers have reported that academic time correlates with achievement (Good, 1983; Peterson & Fennema, 1985), and this study indicates that students who spend more time on science homework have higher achievement in science. As mentioned in Chapter 2, NNES students have additional obstacles in learning science. Spending more time on science learning and science homework would be a good way to conquer the language obstacle.

It was surprising to see that NNES students who had been in a language assistance program had 1.12 lower science achievements than did NNES students who had never been in this type of program. NNES students who had been in an ESL program had 3.46 lower science achievements than did NNES students who had never been in ESL programs. However, this does not mean that the Language Assistance Programs or the ESL programs were not useful. It is possible that only NNES students with serious language inadequency were enrolled in these programs, as the results showed that NNES students who had been in an ESL program had a 0.32 steeper growth rate than did students who had never been in an ESL program. Larger growth rates indicate the effectiveness of these programs in helping improve NNES students' science achievement. Bilingual/ESL Content programs must be effective, well implemented, not segregated, and sustained long enough (5-6 years) for the typical achievement gap between NNES students and native-English speakers to be closed; Even the most effective programs can only close half of the achievement gap in 2-3 years, the typical length of remedial ELL programs; Therefore, short-term, remedial, and ineffective programs cannot close the large achievement gap and should be avoided (Thomas & Collier, 2002).

*The Effect of School Influences on NNES Students' Science Achievement*

One of the purposes of this study was to test various effects of school learning variables on the science achievement of NNES students. For this study, the major factor that influenced the standardized achievement of NNES students was found to be the % of LEP students (1.91) and Emphasis on Learning Science Facts/ Rules (1.07). The most significant, school-level negative predictors of NNES students' science achievement were science taught in non-English language (-2.17) and School Control (-0.62). The most significant, school-level negative predictors of NNES students' science achievement growth were Schools hadn't contacted parents about academic performance (-0.81) and School Control (-0.38).

It was unexpected that NNES students in non-public schools had better predicted science achievements and science achievement growth. NNES students in public schools had 0.62 lower predicted average science achievements than did NNES students in nonpublic schools. NNES students in public schools had average growth rates that were 0.39 lower than NNES students in non-public schools. These results are likely attributed to better teacher-student ratios in non-public schools. NNES students need much more individual attention than other students. Also, nonpublic schools may be better equipped to teach NNES students, rather than public schools were forced into a structure they had to follow.

NNES students in schools that had less than 10% percent of LEP students had 1.91 higher predicted average science achievements. This indicates that NNES students performed better in science in schools that had fewer NNES students. McLaren and Gutierrze (1998) reported that uncredentialed teachers were concentrated in schools serving large percentages of NNES students. Schools having fewer NNES students may have benefits, such as more one-to-one teacher-student interactions and improved classroom climate.

NNES students in schools that taught science in a non-English language had 2.17 lower predicted average science achievements. This result does not mean that science should not be taught in non-English languages to NNES students. It is possible that only NNES students with serious English language inadequacies were taught science in a non-English language because they did not understand English at all and had continued to receive poor science instruction.

It was unexpected that NNES students in schools showing an emphasis on learning science facts and rules had 1.07 higher predicted average science achievements. Science understanding is built upon facts. However, science is not simply about memorizing facts; it is also a method of discovering facts. It is sometimes difficult for NNES student to understand the English instructions for hands-on activities or inquiry investigations. That may have attributed to the higher achievement of NNES students in schools that emphasized learning science facts and rules. Many educators are currently advocating more culturally relevant instruction in science classrooms. I believe this would be one way to improve NNES students' science learning. Culturally relevant instruction refers to teaching based upon students' prior knowledge, which helps students to make sense of their world. It does not refer to a lesson on one cultural group or about the history of one culture. Science had an advantage of allowing students to observe many natural phenomena being taught. Culturally relevant pedagogy involves a great deal of work, but it is worth the effort. I believe that if teachers are exposed more to culturally relevant training in their teacher preparation programs, they will find it much easier to integrate this type of teaching in their classrooms.

Science educators should always remember that science is the *process* of learning, not the "facts" that are learned. Hands-on, inquiry-based instruction provides opportunities for

NNES students to develop scientific understanding, engage in inquiry, and construct shared meanings more actively than with traditional textbook-based instruction (Lee & Fradd, 1998; Rosebery et al., 1992). This is the case for several reasons. First, collaborative, small-group work provides structured opportunities for developing English proficiency in the context of authentic communication about science; Second, inquiry-based science instruction promotes students' communication of their understanding in a variety of formats, including written, oral, gestural, and graphic; Finally, by engaging in science inquiry, NNES students develop their English grammar and vocabulary, as well as their familiarity with scientific genres of writing (Lee, 2005).

Also teachers need to realize that helping students with science texts is not the same as teaching students to read; rather, it is helping students learn from science text. As reading science requires special reading skills — skills that students may not have used in other content areas; for example, in addition to comprehending text passages, students must be able to decode and comprehend scores of scientific signs, symbols and graphics; students also need to read and interpret information presented in unfamiliar ways — not only left to right, but also right to left (equations), top to bottoms (tables), even diagonally (graphs) (Barton, Heidema & Jordan, 2002)..

NNES students in schools that had more parents met by staff had lower predicted average science achievements. This does not mean that having parents as school aides is not helpful. It is likely the case that some parents who go to school to meet staff do so because their children are having problems in the area of behavior or school work. If this is the primary reason that parents meet staff, then the more parents who meet the staff, the more problems their kids have in school. Another result from this study supports this deduction. NNES students in schools that had not contacted parents about academic performance had average growth rates that were

0.80 lower than those of NNES students in schools that contacted parents about academic performance. This shows that when parents are contacted about academic performance, it can be beneficial for NNES students' science achievement. This study suggests the need for school personnel to help raise parents' knowledge, awareness, and involvement in their NNES children's education.

As a conclusion, I believe that different strategies in teaching and guiding will work for increasing the science achievement of NNES students. Although family background and SES are strong factors of NNES students' science achievement, some school policies are also related to science achievement. A successful school will put a highly qualified teacher in every classroom and provided appropriate multicultural education. Additionally, parents can help their children achieve by serving as school aides. Since children spend a great deal of time with their parents, it is invaluable for parents to also serve as educators of their children. Schools should provide suggestions to parents about how to create a positive learning environment at home and encourage parents to become involved in the education of their NNES children. If parents come to school for reasons other than simply being called by staff or teachers, this could also help to improve student achievement.

*Comparisons between NNES and NES students*

Asian students had a statistically significantly better growth rate that did the NES students sample, but it was not a significant factor in the NNES students' sample. Asian students' limited proficiency in English constrains their science achievement when instruction and assessment are undertaken exclusively or predominantly in English. For years, Asian students have been reported to have high science achievement. Asian NNES students had no advantage in learning science. Effective science instruction must consider students' language and culture in relation to pedagogical aims. Asian NNES students also need special help, like other NNES students, due to language inadequencies.

Number of Certified Bilingual or ESL teachers was a statistically significant predictor for the NES students' sample, but it was not significant for the NNES students sample. This indicated that schools with more certified bilingual or ESL teachers had a better predicted science achievement that did NES students. This was an interesting finding, as the bilingual or ESL teachers were expected to be beneficial for NNES students, but not NES students. This may be because schools have more certified bilingual or ESL teachers were of better quality and had greater funding.

It is crucial to identify variables influencing the academic achievement of NNES students, and this study was an attempt to do that. By examining these sources of variation, educators and policy makers will be in a better position to intervene and reverse negative educational trends among NNES students and, ultimately, modify service delivery for improved science learning and development of all students. This study, like all research, raised as many questions as it answered. Some critical areas for future research and practice suggested by the study are provided below.

### *Implications for Future Research on NNES Students' Science Learning*

The results of this study have several implications for future research in the area of NNES students' science learning. First, I suggest a follow-up of the students in this study to see what decisions they made regarding graduation. This will further our understanding of how their school science achievement affects their access to and choice of postsecondary schools and their occupational choices.

Second, research from goal theory and volition theory perspectives can be carried out to understand why some NNES students succeed in maintaining their science achievements, while others do not. Future work can also focus on helping individual NNES students identify their needs, persist with their plans, and take concrete steps to assist with their science learning.

*Implications for Policy Makers*

Analysis of growth trajectories in this study indicates that there is a positive association between average science achievement in the school and acceleration in growth. Hence, we can surmise that schools that emphasize parental involvement and provide academic counseling can produce dramatic effects in science achievement growth for NNES students, because these variables increase the acceleration in academic growth that occurred during the transition from middle school to high school.

NNES students in middle and high schools have many decisions to make regarding the programs in which they participate, the courses they take, their study habits, and their non-academic activities. Communities, families, schools, state governments, religious organizations, and businesses can make a difference and help to increase motivation and awareness, emphasizing the importance of academic performance. Counseling interventions can be developed to address school and family issues for NNES students. Counselors can help NNES students understand their options, identify their goals, and get into suitable language assistance programs. Students and parents from lower socioeconomic backgrounds should be provided with information about various financial packages available in an effort to increase motivations in study science. Parents who refuse bilingual/ESL services for their children should be informed that their Children's long-term academic achievement will probably be much lower as a result, and they should be strongly counseled against refusing bilingual/ESL services when their child is eligible (Thomas & Collier, 2002).

### *Implications for Research Practice*

This study used a national database to study NNES students' science achievement over time. There are several significant advantages to using such a database. The sample is nationally representative, and sampling has been done with care to account for factors such as nonresponse. Methods have also been devised to account for issues such as oversampling that are related to the complex sampling process. Data have been gathered at many levels (e.g., schools, students, and teachers). It is sometimes difficult for individual researchers to conduct a large longitudinal study, and the availability of existing longitudinal data enables the researcher to examine various substantive and methodological issues. Much of the research in the area of NNES students' science achievement is based on small-sample local studies, limiting the generalizability of the results. This study, in using the NELS:88 database, overcomes many limitations associated with small-sample studies and studies done at one point in time. The representativeness of the sample, the thoroughness of the data collection, the ability to address a number of issues, and the use of a variety of analytical techniques has enabled this study to address a variety of issues and come up with important implications for research practice.

This study also sought to overcome the deficiencies found in many past studies using large national databases such as NELS. Many prior studies did not take into account the complex sampling methods used in the collection of these national data sets. This study accounted for the complexity of the sampling design, and other issues like nonresponse and oversampling, by using the appropriate design weights. According to NCES (1994), if weights are not used, “the estimates that we produce will not be representative of the population about which we are attempting to estimate.”

This study used hierarchical linear modeling as the data analysis tool. Growth modeling techniques in hierarchical linear modeling allowed the study of students’ achievements over time. Hierarchical linear modeling has several advantages over other repeated measures techniques, such as multivariate ANOVA. Ware (1985) concludes that the multivariate approach is of limited use when there are missing data, unbalanced designs, time-varying covariates, or continuous predictors of the rate of change. According to Raudenbush and Chan (1993), such characteristics are common in large-scale longitudinal studies. Hierarchical linear modeling is a more flexible approach for modeling such data. Hierarchical linear modeling also allows the assessment of correlates of growth, enabling in-depth study of student achievements as a dynamic process. In this study, results from hierarchical linear modeling revealed that background, academic, school, and parental factors all had impact on NNES students’ science achievement. HLM methods were also used to investigate school-level factors using three-level modeling. One of the limitations of HLM is that it treats the population distribution of growth as continuous. The assumption is that the functional form of the growth is the same for all of the observations and that only the parameters of growth vary. Because of this assumption, HLM only allows the investigation of “average” growth tendencies and the study of variability about that average. It also attempts to explain this variability about the average using covariates of interest. However, in situations where it is not reasonable to assume that all participants are growing in the same functional form or that the development does not vary regularly among the population, the use of hierarchical linear modeling is limiting. This study is exploratory in nature, as NNES students' science achievement growth trajectories have not been investigated in depth in earlier studies.

### *Limitations and Next Steps*

One of the methodological limitations of this study was that only three data points were used in the analyses. This limited the exploration of the variety of options available in fitting hierarchical models, such as being able to fit higher order models. A next step would be to use a fourth data point for NNES students' science achievements from the 1994 wave of NELS: 88 data. This was not used in this study, as it would have involved addressing very different substantive questions. This study used hierarchical linear modeling methods for longitudinal modeling. There are other techniques, such as growth mixture modeling from a latent class modeling perspective, which can also offer insights into this data. Growth mixture modeling is a relatively new procedure for the analysis of longitudinal data that relaxes many assumptions associated with conventional growth curve modeling. In particular, growth mixture modeling tests for the existence of unique growth trajectory classes through a combination of latent class analysis and standard growth curve modeling (Kaplan, 2001).

Another limitation of this study was the use of existing dated data, which did not allow the researcher control over the definition of variables, the questions used, or the response categories. However, the national data set used had many indicators of the variables the researcher wished to use, allowing the researcher to formulate more specific variables. A qualitative component to the study would also help to overcome the limitations imposed by rigid variable and question design. Qualitative methods such as ethnography and case study analysis would help shed more light on the search stage of the college choice process, where students narrow the choice set of postsecondary institutions to which they wish to apply.

Finally, even though this study uses longitudinal data, it is an exploratory study, and the relationships inferred are correlational. Care should be taken not to interpret the results using logical causal relationships. To further substantiate the results from this study, more evidence-based experimental or quasi-experimental studies can be conducted in the future.

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## APPENDIX A

## NELS:88 VARIABLES CONSIDERED IN THIS STUDY

Student Characteristics

| | |
|---|---|
| SEX | Respondent's gender |
| RACE | Respondent's ethnicity |
| BYSES | Socio-economic status composite |
| BYS29 | Ever in a language assistance program |
| BYSC45B3 | Science taught in non-English language |
| F1S34D | Ever been in English as a second language program |
| BYS79B | Time spent on science homework each week at 8th grade |
| F1S36C1 | Time spent on science homework in school at 10th grade |
| F1S36C2 | Time spent on science homework out of school at 10thgrade |
| F2S25B1 | Time spent on science homework in school at 12th grade |
| F2S25B2 | Time spent on science homework out of school at 12th grade |

School Background

| | |
|---|---|
| BYSC15 | Percent of 8th graders Non-native English Speaking |
| BYSC22 | Number of teachers teaching NNES, ESL, etc. |
| BYSC45A | 8th grade English taught to NNES students |
| F1C29 | Percent of 10thgrade language minority, NNES students |

| | |
|---|---|
| F2C24 | Percent of 12th grade language minority, NNES students |
| BYP57A | Parents contacted about academic performance |
| F1S30B | Emphasis on learning science facts/rules |
| G8CTRL | School control composite |
| F1C45 | Number of teachers assigned to ESL class |
| F1C46 | Number of certified bilingual or ESL teachers |
| F1C78 | Number of Language Minority students in AP courses |
| BYSC16E | Percent of students in ESL (8th grader) |
| F1C30G | Percent of students in ESL (10th grader) |
| F2C25G | Percent of students in ESL (12th grader) |
| BYT2_6 | Number of LEP students in class |
| BYT5_6 | Number of LEP students in class |
| F1T2_8 | Number of LEP students in class |
| F1T6_8 | Number of LEP students in class |

Family Background

| | |
|---|---|
| BYPARED | Parent's highest education level |
| F1C100 | Number of parents staff meet |
| BYS35M | Family has more than 50 books (8th grader) |
| F1N21M | Family has more than 50 books (10th grader) |
| F2N12M | Family has more than 50 books (12th grader) |
| BYS42A | Number of hours watches TV on weekdays (8th grader) |
| BYS42B | Number of hours watches TV on weekends (8th grader) |

| | |
|---|---|
| F1S45A | Number of hours watches TV on weekdays (10th grader) |
| F1S45B | Number of hours watches TV on weekends (10th grader) |
| F2S35A | Number of hours watches TV on weekdays (12th grader) |
| F2S35B | Number of hours watches TV on weekends (12th grader) |
| BYS22 | Language spoken in student's home |

Dependent Variables

| | |
|---|---|
| BY2XSIRR | Science IRT-estimated score at 8th grade |
| F12XSIRR | Science IRT-estimated score at 10th grade |
| F22XSIRR | Science IRT-estimated score at 12th grade |

APPENDIX B

CHARACTERISTICS OF THE STUDENT SAMPLE BASED ON THE VARIABLES INCLUDED IN THE STUDY

| Independent Variables | Label | Construct | Mean | *SD* | Min | Max |
|---|---|---|---|---|---|---|
| Composite SEX | SEX | Dummy Coding | 0.49 | 0.50 | 0.00 | 1.00 |
| SES Composite | BYSES | No Recode | -0.01 | 0.79 | -2.97 | 1.85 |
| Race (American Indian) | AMERIND | Dummy Coding (from RACE) | 0.01 | 0.10 | 0.00 | 1.00 |
| Race (Asian) | ASIAN | Dummy Coding (from RACE) | 0.06 | 0.24 | 0.00 | 1.00 |
| Race (Black) | BLACK | Dummy Coding (from RACE) | 0.10 | 0.30 | 0.00 | 1.00 |
| Race (Hispanic) | HISPANIC | Dummy Coding (from RACE) | 0.12 | 0.32 | 0.00 | 1.00 |
| Race (White) | WHITE | Dummy Coding (from RACE) | 0.71 | 0.45 | 0.00 | 1.00 |
| Ever in a Language Assistance Program | BYS29 | Dummy Coding | 0.17 | 0.16 | 0.00 | 1.00 |
| Time Spent on Science Homework each week (8th) | BYS79B | Dummy Coding | 0.61 | 0.48 | 0.00 | 1.00 |
| Time Spent on Science Homework in school each week (10th) | F1S36C1 | Dummy Coding | 0.72 | 0.44 | 0.00 | 1.00 |
| Time Spent on Science Homework out of School each week (10th) | F1S36C2 | Dummy Coding | 0.61 | 0.49 | 0.00 | 1.00 |
| Ever been in an ESL program | F1S34D | Dummy Coding | 0.11 | 0.31 | 0.00 | 1.00 |
| Time Spent on Science Homework in School each week (12th) | F2S25B1 | Dummy Coding | 0.21 | 0.39 | 0.00 | 1.00 |
| Time Spent on Science Homework out of School each week (12th) | F2S25B2 | Dummy Coding | 0.71 | 0.45 | 0.00 | 1.00 |
| Parents' Highest Education Level | BYPARED | Dummy Coding | 0.32 | 0.47 | 0.00 | 1.00 |
| Family has more than 50 Books (8th) | BYS35M | Dummy Coding | 0.91 | 0.29 | 0.00 | 1.00 |
| # of Hours Watch TV on Weekdays (8th) | BYS42A | Dummy Coding | 0.12 | 0.31 | 0.00 | 1.00 |
| # of Hours Watch TV on Weekends | BYS42B | Dummy Coding | 0.25 | 0.41 | 0.00 | 1.00 |
| Language Spoken in Student's Home | BYS22 | Dummy Coding | 0.44 | 0.23 | 0.00 | 1.00 |
| Family has more than 50 Books (10th) | F1N21M | Dummy Coding | 0.91 | 0.29 | 0.00 | 1.00 |

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| # of Hours Watch TV on Weekdays (10th) | F1S45A | Dummy Coding | 0.08 | 0.27 | 0.00 | 1.00 |
| # of Hours Watch TV on Weekends (10th) | F1S45B | Dummy Coding | 0.21 | 0.40 | 0.00 | 1.00 |
| Family has more than 50 Books (12th) | F2N12M | Dummy Coding | 0.91 | 0.29 | 0.00 | 1.00 |
| # of Hours Watch TV on Weekdays (12th) | F2S35A | Dummy Coding | 0.08 | 0.26 | 0.00 | 1.00 |
| # of Hours Watch TV on Weekends (12th) | F2S35B | Dummy Coding | 0.22 | 0.42 | 0.00 | 1.00 |
| School Control Composite | G8CTRL | Dummy Coding | 0.76 | 0.42 | 0.00 | 1.00 |
| % of LEP(8th) | BYSC15 | Dummy Coding | 0.90 | 0.28 | 0.00 | 1.00 |
| # of teachers teaching LEP, ESL | BYSC22 | Dummy Coding | 1.30 | 2.51 | 0.00 | 1.00 |
| English Taught to NNES students (8th) | BYSC45A | Dummy Coding | 0.32 | 0.45 | 0.00 | 1.00 |
| Parents Contacted about Academic Performance | BYP57A | Dummy Coding | 0.43 | 0.28 | 0.00 | 1.00 |
| # of Students in ESL (8th) | BYSC16E | Dummy Coding | 0.96 | 0.18 | 0.00 | 1.00 |
| Science Taught in Non-English Language | BYSC45B 3 | Dummy Coding | 0.32 | 0.45 | 0.00 | 1.00 |
| % of LEP students (10th) | F1C29 | No Recode | 1.04 | 1.03 | 0.00 | 5.00 |
| # of Teachers assigned to ESL class | F1C45 | No Recode | 1.19 | 2.70 | 0.00 | 33.69 |
| # of Certified Bilingual or ESL teachers | F1C46 | No Recode | 0.85 | 2.22 | 0.00 | 33.61 |
| # of Language Minority students in AP courses | F1C78 | No Recode | 8.16 | 20.15 | 0.00 | 350.00 |
| % of Students in ESL (10th) | F1C30G | Dummy Coding | 0.94 | 0.21 | 0.00 | 1.00 |
| # of Parents Staff Meet | F1C100 | No Recode | 244.59 | 279.81 | 0.00 | 4000.00 |
| Emphasis on Learning Science Facts/Rules | F1S30B | Dummy Coding | 0.32 | 0.33 | 0.00 | 1.00 |
| % of LEP students (12th) | F2C24 | Dummy Coding | 0.81 | 0.79 | 0.00 | 1.00 |
| % of Students in ESL (12th) | F2C25G | Dummy Coding | 0.90 | 0.24 | 0.00 | 1.00 |