PARENT INVOLVEMENT AND SCIENCE ACHIEVEMENT: A LATENT GROWTH CURVE ANALYSIS

Ursula Yvette Johnson, BS, MA

Dissertation Prepared for the Degree of

DOCTOR OF PHILOSOPHY

UNIVERSITY OF NORTH TEXAS

August 2011

APPROVED:

Darrell Hull, Major Professor
Arminta Jacobson, Committee Member
Prathiba Natesan, Committee Member
Kim Nimon, Committee Member
Abbas Tashakkori, Chair of the Department of Educational Psychology
Jerry Thomas, Dean of College of Education
James D. Meernik, Acting Dean of the Toulouse Graduate School

Johnson, Ursula Yvette. Parent involvement and science achievement: A latent growth curve analysis. Doctor of Philosophy (Educational Research), August 2011, 1мл pp., 15 tables, 4 illustrations, 86 titles.

This study examined science achievement growth across elementary and middle school and parent school involvement using the Early Childhood Longitudinal Study – Kindergarten Class of 1998 – 1999 (ECLS-K). The ECLS-K is a nationally representative kindergarten cohort of students from public and private schools who attended full-day or half-day kindergarten class in 1998 – 1999. The present study's sample (N = 8,070) was based on students that had a sampling weight available from the public-use data file. Students were assessed in science achievement at third, fifth, and eighth grades and parents of the students were surveyed at the same time points. Analyses using latent growth curve modeling with time invariant and varying covariates in an SEM framework revealed a positive relationship between science achievement and parent involvement at eighth grade. Furthermore, there were gender and racial/ethnic differences in parents' school involvement as a predictor of science achievement. Findings indicated that students with lower initial science achievement scores had a faster rate of growth across time. The achievement gap between low and high achievers in earth, space and life sciences lessened from elementary to middle school. Parents' involvement with school usually tapers off after elementary school, but due to parent school involvement being a significant predictor of eighth grade science achievement, later school involvement may need to be supported and better implemented in secondary schooling.

ACKNOWLEDGEMENTS

I acknowledge the valued support and contributions of my dissertation committee, Darrell Hull, Kim Nimon, Prathiba Natesan, and Arminta Jacobson, during the development of this manuscript. Also, I thank the following family, friends, and mentors for their lasting support, positive thoughts, and guidance on this doctoral path: Charlotte Johnson, Brandie Ariel Tinker, Sylvester Johnson, Marilyn Green, Atra B. Greene, Denise Longoria Lopez, Sheila Haferkamp, Shelly Ludeman, and Susan Landry.

Education is an ornament in prosperity and a refuge in adversity.

- Aristotle

TABLE OF CONTENTS

LIST OF TABLES

Page

LIST OF FIGURES

PARENT INVOLVEMENT AND SCIENCE ACHIEVEMENT: A LATENT GROWTH CURVE ANALYSIS

Introduction

Growth and achievement in science is critical to ensure a diverse and talented labor force for the highly skilled scientific and technological careers that will dominate the global labor field. While other educational domains, such as reading and math, have been the focus of previous educational research and policy, science education research has increased recently (e.g. Gorad & See, 2009; Haworth, Dale & Plomin, 2009; Ma & Wilkins, 2002; Parsons, 2007). For example, the United States' No Child Left Behind Act of 2001, 20 U.S.C. § 6319 (2008) required the nation's K -12 public schools to use research-based methods to develop science curricula and to measure science growth, and to establish partnerships with universities to increase science achievement. In addition, science education is perceived as important for all citizens because of the scientific understanding necessary in daily lives; therefore, science is not solely for those who pursue scientific or technical careers (Feinstein, 2011). From a human capital standpoint, a student's knowledge and understanding of science impacts their future educational and occupational opportunities (Horn & Kojaku, 2001; Jacobs, 2005; Levine & Zimmerman, 1995).

The science academic performance of children and adolescents is associated with heritability and environmental influences (Haworth et al., 2009). Specifically, in a twin study, nine-year-olds showed high heritability, while 12-year-olds had significantly higher shared environmental influences regarding science achievement. One obvious shared environmental influence is family factors, such as parent involvement. Recent meta-analyses of parent involvement in elementary and secondary education showed that different types of parent involvement were positively related to student academic achievement (Jeynes, 2005; Jeynes, 2007). Previous research on science achievement has mainly focused on secondary education because of its effect on later outcomes in education and occupational choice. Few research studies have modeled science achievement growth and its relation to parent involvement across elementary and early secondary schooling. The purpose of the present study was to extend previous research by examining the developmental course of science achievement from third to eighth grade, as it relates to parent involvement.

Parent Involvement and Achievement

Parent school involvement is generally defined as parents' communication and participation with schools and their children to increase child academic outcomes. In research studies, parent school involvement is usually operationalized as parents attending events at school, contacting school, and volunteering at school (Fan & Chen, 2001; Hill & Tyson, 2009; Hong & Ho, 2005; Jeynes, 2005; Jeynes, 2007). Previous research suggested that actions, such as attending parent teacher conferences and PTO/PTA meetings, and volunteering in the school are positively related to academic achievement (Hill & Tyson, 2009).

Other factors, such as race/ethnicity and socioeconomic status (SES), may affect the findings of parental involvement on student achievement. Domina (2005) found that after controlling for student variables (prior academic achievement, gender, race, grade, and public school vs. private school) and family background variables (socio-economic status and two-parent vs. single-parent family), parent involvement (attending school events, volunteering at the school, and help with homework) was negatively related or not significantly related to child's academic achievement. Prior literature is inconsistent regarding parent involvement and student achievement, and almost non-existent concerning parent school involvement and elementary to early secondary school science achievement, and its differential effects for different race/ethnicity groups. Therefore, parents' involvement in their children's elementary and secondary academic life is a salient topic.

Theoretical Framework

Cultural and social capital frameworks underpinned the present study as it examined how students' academic achievement may be increased through parental resources and relationships. Bourdieu's (1986) concept of social reproduction states that differences in culture and social classes give individuals social and cultural capital that can be used to benefit themselves and others. Individuals that are part of the dominant culture are rewarded by the educational system because of their shared values, mores, relationships and resources. Children from non-Hispanic White (hereby referred to as White) families that are middle- to upper-class are exposed to their parents' cultural capital in the home, which allows for an easier transition to school and experience in school because of the similar social and cultural expectations and relationships from their home environment.

Cultural capital, as measured by parents' social class position, widens or narrows a parent's access to resources to participate in their child's school life as expected by the child's teacher (Lareau, 1987). Lareau found that parents from low-income and middle-income backgrounds want their children to succeed in school, but they take different paths to encourage and support their child's academic success. Middle-class families were able to be involved in their children's education in ways that the teacher requested, such as monitoring homework, supervising child's time at home and communicating with the teacher. In comparison, working-class families expected teachers to focus on educating their children and the families focused on other dimensions of the child's development.

Lee and Bowen (2006) used Bourdieu's cultural capital framework to study the impact of parental involvement on elementary school students' achievement. They found that there were different levels of parental involvement amongst parents of different SES. Parents that were involved at the school and had high educational aspirations for their children (beliefs of the dominant culture) were positively related with student academic achievement. Lee and Bowen demonstrated that all families benefitted from some dimensions of parental involvement; therefore, they partially supported Bourdieus's concept of cultural capital.

Bourdieu (1986) and Coleman and Hoffer (1987) agree that social capital is an intangible resource that allows individuals to use social networks for their own gain. A child's human capital can be improved by the human capital of the parent through the parent's social capital, which is the involvement the parent has with the child and with the teacher (Coleman & Hoffer, 1987). Coleman and Hoffer found that parents that were intricately involved in their child's educational life at school and at home increased the child's student achievement.

McNeal (1999) found support for the social capital framework with a positive finding of a relationship between parental support and achievement. However, the results changed when race/ethnicity, SES, and family structure were controlled. White students from two-parent middle-income households benefitted from parental involvement, but other students and family types did not. This provides some evidence for the cultural capital theory that students from the dominant culture are advantaged by the cultural capital (and so it seems social capital) of their parents through parental involvement that resulted in increased student achievement.

Previous research suggests a positive relationship between parent involvement and academic achievement, although links to science achievement across elementary and early secondary education is less clear.

Research Questions

The purpose of the present study was to examine the relationship between parental involvement and science achievement across third through eighth grade. The present study: a) modeled the science achievement growth of students in elementary and middle school, b) examined the differential science achievement growth trajectories of students' by race/ethnicity, and c) examined parental involvement behaviors that relate to students' science achievement growth, above and beyond the developmental trajectory. Specifically, the research questions are:

1. What is the average initial level and growth trajectory of students from third grade to eighth grade in science achievement?
2. To what extent does initial level of science achievement relate to growth in science achievement?
3. Is parent school involvement significantly associated with students' science achievement growth, while controlling for school-level variables and parents' socioeconomic status?
4. Does the parent school involvement and science achievement relationship differ amongst race/ethnic groups, while controlling for school-level variables and parents' socioeconomic status?

Method

Sample

The Early Childhood Longitudinal Study – Kindergarten Class of 1998-1999's (ECLS-K) kindergarten through eighth grade data set was used for the present study. The ECLS-K sampled a nationally representative kindergarten cohort of students from public and private schools who attended full-day or half-day kindergarten class in 1998 – 1999. The kindergarten to eighth grade full sample public-use data file was used in the present study because it combined data from the base (kindergarten), first, third, fifth, and eighth grade years, which allowed examination of students' growth and development from elementary to middle school.

A three-stage probability sampling design was conducted at the base year to form a nationally representative cohort of kindergartners (Tourangeau, Lê, Nord & Sorongon, 2009). Oversampling was employed for Asians and Pacific Islanders (API) at a rate of 2.5 APIs for every one non-API at a school. Therefore, weights were employed in the present study because of the probability sample design and oversampling techniques. Conducting analyses without utilizing sampling weights can lead to biased parameter estimates, test statistics, and confidence intervals (Hahs-Vaughn, 2005). The ECLS-K longitudinal weight, C567PWO, was transformed into a normalized weight (dividing the raw weight by its mean) to account for the disproportionate sampling.

Outcome Variable

Students completed the science assessment in the springs of third grade, fifth grade, and eighth grade. Item response theory science scores are used in the present study because they are comparable across different forms of an assessment and can be used to show growth over time. Science was not assessed until third grade with life, earth and space science areas given equal weight in content of the assessment (Tourangeau, Lê, Nord & Sorongon, 2009). The science assessment examined students' scientific skills, such as interpreting data, formulating hypotheses, and planning an investigation. Additionally, students' ability to draw inferences and understand relationships about things in the physical and natural world was analyzed by the assessment.

Time Invariant Covariates

The school-level variables are school type, school location, and percentage of free lunch eligible students in each school. The data was collected in the spring of third grade. School type was public school (coded as 0) and private school (coded as 1). School location was divided into three categories: large city (population equal or greater than 250,000) to mid-sized city (population less than 250,000), suburban area or large town (population greater than or equal to 25,000), and small town (population less than 25,000) or rural area and dummy coded into two variables. The percentage of students eligible for free lunch in school is a continuous variable.

Time Varying Covariates

Family SES was computed from parents' education and occupations and household income (Tourangeau, Lê, Nord & Sorongon, 2009). SES is a continuous composite variable and data was collected in the springs of third, fifth, and eighth grades. The SES variable is included as a time varying covariate because it is not a static covariate.

There were nine parent involvement related items common to the parent survey across third, fifth, and eighth grade administrations. To evaluate the factor structure of the items, factor analysis was conducted to determine and confirm the factor structure of the parent involvement items using Mplus 6.0 (Muthen & Muthen, 2010). The sample was randomly divided to conduct exploratory factor analyses (EFA) and confirmatory factor analyses (CFA). One factor, labeled parent school involvement, was extracted from each time point using the robust weighted least squares estimator. The factor included five items asking parents about their participation in open house, parent-teacher organization, school events, fundraising, and volunteering and the response scale was dichotomous (yes/no). Goodness-of-fit test indices for the CFAs showed good model fit to the sample data; root mean square error of approximation (RMSEA) index were .036, .051, and .056, comparative fit index (CFI) values were .99, .97, and .99, and normed fit index (NFI) values were .98, .97, and .97 at third grade, fifth grade, and eighth grade, respectively. Internal consistency was assessed by Cronbach's alpha, which was .587, .592, and .617 at third, fifth, and eighth grades, respectively.

Factors scores are usually used to rank an individual on a factor or compare how groups differ on a factor, but the scores were not used in the present study. Factor scores are sensitive to the type of factor extraction and rotation methods used to obtain the factor solution and the scores are likely to be non-normal (DiStefano, Zhu & Mîndrilă, 2009). Therefore, BILOG-MG 3 (Zimoski, Muraki, Mislevy, & Bock, 2007) was used to obtain theta estimates for the parent school involvement latent variable. Theta estimates transformed the latent variable into a continuous variable with a mean of zero and standard deviation of one that was normally distributed. Parent involvement is a dynamic process, with parents changing their involvement behaviors from elementary school to middle school. Therefore, by including parent school involvement as a time varying covariate, the change in this latent variable can be modeled at each time point.

Grouping Variable

Race/ethnicity was included from the fall kindergarten data collection time point and was categorized as African American, Asian American, Hispanic, and White.

Analytic Approach

Latent Growth Curve Modeling

Latent growth curve modeling (LGM) using a structural equation modeling framework was used to estimate interindividual and intraindividual changes in students' science achievement development from third grade to eighth grade. To examine the developmental trajectories of science achievement among students over time as predicted by parent school involvement and other covariates, the present study conducted LGMs using Mplus Version 6.1 (Muthen & Muthen, 2010).

LGM allows examination of a single student's growth trajectory and individual differences in growth over time (Duncan, Duncan & Stryker, 2006). Additionally, this methodology permits the researcher to study predictors of these individual differences and determine which predictors relate to rates of change in development. Usually, two latent parameters are estimated in LGM, indicator intercepts and slopes (i.e. factor means). The intercept represents the initial status of the growth curve for all students and the slope represents the linear growth across the time points.

Two models are estimated in the SEM framework for LGM, the unconditional model and conditional model. Unconditional latent growth curve models examine growth over time without predictors to determine the mean intercepts and slopes and the presence of variability around the means. Once the unconditional models are found to be statistically significant for interindividual differences among the students' scores and rates of change, the time invariant and time varying covariates are included in the conditional model to predict the differences. Goodness-of-fit test indices are used to evaluate model fit to the sample data (Hu & Bentler, 1999).

Multiple-Group LGM

Multiple-group LGMs were used to test invariance of parameters across gender and ethnic groups. An advantage of this approach is to analyze multiple groups at the same time, instead of separately (Duncan, Duncan, & Strycker, 2006). One approach to test for invariance is to develop a series of nested models where the baseline model has no constraints and the following models add constraints. The alternative model (one with constraints) is compared to the baseline model by a chi square test, which if statistically significant, the constraint should be removed, indicating the parameter differs across groups. If the chi square difference test is not statistically significant, this means that constraining the parameters across groups did not deteriorate the model fit, indicating invariance. The parameters of interest in the present study are intercept, slopes, variances, and covariance. Absolute and relative fit indices are also used to determine which model fit the data better.

The maximum likelihood estimation with robust errors (MLR) was used in the LGM analyses, which is robust to non-normality and non-independence of observations (Muthen & Muthen, 2010). When using MLR, the reported chi square is a scaled chi square and different calculations have to be performed when conducting chi square difference tests with the scaling correction factor (Satorra & Bentler, 1999). A calculator for the chi square difference test for MLR, which is based on Satorra and Bentler's (1999) calculations, was used for the present study (Colwell, n.d.).

Missing Data

Missing data is expected in longitudinal research, particularly if students change schools and there are transitions between data collection periods, such as promotion to middle school from elementary school. The results from the present study are based on the students that had a sampling weight available from the kindergarten through eighth grade data file. There were 8,070 cases for the science achievement sample and missing rates were not over 5 % for any variable. Multiple imputation, using the Amelia II package (Honaker, King, and Blackwell, 2009) in R, was conducted for the present study. Five imputations were performed on independent and dependent variables, which were then used in further analyses. Parameter estimates and standard errors were pooled across the five imputed data sets.

Results

Table 1 presents descriptive statistics for the sample. The sample (N = 8,070) included 50.9 % females and 64.7 % White students. Most students at third grade attended public school (79.0 %) and their school was located in large to mid-size cities (34.9 %), large to mid-size suburbs and large towns (39.3 %), and in small towns or rural areas (25.8 %). The average third-grader attended school where 28.1 % of the school's student population was eligible for free lunch. Parents' socioeconomic status, defined as their education, income, and occupation, was slightly above the mean of zero at all three time points, while the parent school involvement factor was slightly below the mean of zero. The science achievement outcome variable grew linearly across third to eighth grade (see Figure 1).

Unconditional Model

An unconditional latent growth curve model was developed for the full sample to identify the trajectory of science achievement growth from third to eighth grade. Loadings for the intercept factor were fixed at 1 to represent the initial level of growth at third grade. The paths from the slope factor to the outcome measures were also fixed at 0, 2, and 5 to reflect the time between measurements of science achievement. Third grade was the base year and therefore the slope loading was set at 0, the next measurement occasion was in fifth grade, two years later, and the last measurement occasion was in eighth grade five years after the base year.

Model 1 is the unconditional linear model, which demonstrated reasonable fit to the sample data (see Table 2). Table 3 has the model's parameter estimates for the intercept and slope means, variances and covariance. The results of the unconditional linear model indicated that the average initial level of science achievement was 50.486 and had a mean slope of 6.478, meaning that students grew at an average rate of 6.5 points per year in science achievement. The intercept and slope variances were statistically significant, which indicated that there was interindividual difference among students' science achievement scores across time. In addition, the statistically significant covariance between intercept and slope signified students with a low science achievement score initially had a higher rate of growth.

Conditional Models

Time Invariant Covariates

Model 2 is the conditional that examined the time invariant school-level variables' relationship with science achievement growth. As shown in Table 2, the fit of Model 2 was acceptable and improved upon the unconditional model's fit. The parameter estimates indicated students that attended schools with increased percentages of free lunch recipients had lower initial science achievement scores at third grade and decreased growth in achievement across the three time points. Additionally, students that attended schools in suburban areas or large towns had a decline in science achievement growth from third to eighth grade. School type was not a significant predictor of science achievement initial level or growth.

Time Varying Covariates

Model 3 is a conditional model, which includes the time-invariant covariates and the time varying covariate, SES; model fit was acceptable. The school-level variable parameter estimates were similar to Model 2, except in Model 3 suburban schools were positively associated with science achievement intercept. SES's was positively related to science achievement scores at third, fifth, and eighth grades after taking into consideration individual student differences accounted for by the intercept and slope; meaning that students whose families had increased SES scores tended to have increased science achievement scores.

Model 4 is the final full theoretical model that includes the school-level, SES, and parent involvement variables. Model 4 was a slight improvement over the previous model's fit. In this model, the school-level variables' and the SES variable's relationships with the intercept and slope were the same as in Model 3. The parent school involvement factor was statistically significant at eighth grade only, after partialing out individual differences and the developmental trajectory; higher parent school involvement scores was related to higher eighth grade science achievement scores.

Multiple-Group Growth Models

Model 5a is the unconstrained multiple-group LGM that examined science achievement trajectories across third through eighth grades for different ethnic groups; model fit was acceptable. Parameter estimates for the latent variables were statistically significant for all ethnic groups. In third grade, White students had the highest initial science achievement score (59.464), followed by Asian American students (55.901), Hispanic students (53.511), and African American students (49.128). During third through eighth grade, the rate of science achievement growth from highest to lowest was Hispanic students, White students, Asian American students, and African American students.

Since there were differences in mean intercepts and slopes amongst the ethnic groups, Model 5b was constructed to test invariance across those parameters. The statistically significant chi-square difference test using the scaling correction factor indicated group differences of the intercept and slopes; therefore, Model 5a was retained. Model 5c was developed to test the invariance of variances and covariance for ethnic groups' growth in science achievement. The chi-square difference using the scaling correction factor was statistically significant, which indicated that there were ethnic differences for science achievement growth as it pertained to variance and covariance residual variance.

Consequently, Model 5a was accepted and the parameter estimates are in Table 4. Figure 3 represents the science achievement growth of students disaggregated by race/ethnicity.

For the African American and White sub-samples, the free lunch variable was negatively related to the intercept, indicating that African American and White students in high poverty schools scored lower on the science achievement assessment initially. The time varying SES covariate was positively related to science achievement from third to eighth grades for both sub-samples. The parent school involvement latent factor was not statistically significant for either group.

Asian American students' initial score on the science assessment was negatively related to their attendance in high poverty schools and suburban schools. SES was positively related to science achievement growth at all time points. As Asian American parents increased their parent school involvement in fifth grade, their children's science achievement growth increased as well in fifth grade.

Hispanic students' science achievement score in third grade was negatively related to their attendance in schools with high percentages of free lunch participants and attendance in suburban schools had a decline in growth rate across third through eighth grades. Hispanic families that scored high on the SES variable had increased science achievement growth in third, fifth, and eighth grades. Additionally, Hispanic parents that reported increased parent school involvement participation at fifth and eighth grades had children with science achievement growth at the same time points, after controlling for other variables and beyond the general science achievement growth.

Discussion

The present study examined developmental trajectory of science achievement across elementary and middle school, and the relationship of parent involvement to these achievement trajectories. Specifically, average initial status and rate of growth of students from third grade to eighth grade in science achievement was investigated. Parent school involvement and SES were measured at third, fifth, and eighth grades to predict science achievement at each time point, while controlling for school-level SES, school's location, and student's attendance in public or private school. In addition, differential effects of race/ethnicity on science achievement growth were investigated.

The aims of gaining scientific knowledge are twofold: a) the preparation of school-aged children to further future economic progress in a technologically-based global society and b) building science literacy in the general population to understand the natural world through observation and measurement (American Association for the Advancement of Science, 1998; Millar, 2008; Rutherford & Ahlgren, 1991). Education reform, specifically the No Child Left Behind Act of 2001, 20 U. S. C. § 6319 (2008), focuses on improving academic achievement and closing achievement gaps. The science achievement results in the present study provides evidence that lower performing students at third grade grew at a faster rate than their high achieving peers in gaining scientific knowledge, thus the science achievement gap between high and low performers is closing. Significant scientific knowledge was gained in life, earth, and space science domains from third to eighth grade.

Parent Involvement and Achievement

The findings suggest that high parent involvement behavior at eighth grade is significantly associated with increased science achievement at the same grade, beyond individual student differences and the normal developmental trajectory. This result concurs with previous literature that found a moderate relationship between school-based parent involvement and middle school achievement (Hill & Tyson, 2009). In the present study, parents' participation in school events, fundraising, parent-teacher organization, and volunteering activities and attending open house was positively related to their children's science achievement scores in eighth grade.

We suggest that a theory of social capital would explain limitations on parents' ability to participate fully in school activities, as their social status prevents them from doing so. The present study supports this theoretical framework because social capital plays an important role in human capital, "the norms, the social networks, and the relationships between adults and children" (Coleman & Hoffer, 1987, p. 36) influences the academic achievement of students. The parent school involvement behaviors in the present study, such as attending school events, participating in the PTO/PTA, fundraising, and volunteering, all increase the social capital of the parents. Parents that are involved in the school learn the rules and structure of the educational system, while increasing their social network by the relationships that are formed through the school-related activities. Social capital benefits students positively because it is a resource where responsibilities and expectations are conferred to them by their parents because of the parents' access to information, norms, and social structure gained from the school social environment (Coleman, 1988). Hence, parents' time and effort (social capital) spent with children can create human capital (better school outcomes) for their children.

From a cultural capital viewpoint, schools' policies and practices highly value a specific type of parent involvement, one that includes parents and schools working together to educate children, such as being involved in the school (Lareau and Weininger, 2003). Therefore, parents "strategic use of knowledge, skills, and competence come into contact with institutionalized standards of evaluation" (Lareau & Weininger, 2003, p. 597) with some families benefitting from their ability to meet the expectations of institutional standards. According to this framework, schools highly value the parenting skills of the dominant group, White, middle to high SES families, while devaluing other parenting skills. Schools do not always acknowledge that all parents across ethnic and social class groups are not capable or knowledgeable of the dominant group's valued style of parenting. This theory was supported by the present study with the significant relationship between parent school involvement and science achievement at eighth grade. It remains unclear why parent involvement was less significant in earlier grades, but it is likely that the mutidimensional nature of parent involvement was not fully captured in the present study with the measures available.

Parent involvement is a multi-dimensional domain that can broadly be divided into home-based involvement, school-based involvement and parents' educational aspirations for children. Home-based involvement includes parents supervising children's time at home and communicating with children about academic issues; school-based involvement includes parents attending events at school, contacting the school, and volunteering at the school; and the third dimension, educational aspiration, includes parents' educational expectations for children (Fan & Chen, 2001; Hong & Ho, 2005; Jeynes, 2005; Jeynes, 2007). The present study examined only school-based involvement, which is not as strongly related to academic achievement as the educational aspiration parent involvement domain (Fan & Chen, 2001; Hill & Tyson, 2009; Jeynes, 2005); possibly explaining the present study's significant finding with a small effect. In previous studies, middle school student academic achievement and parents' education aspirations had greater impact than other parent behaviors with effect sizes over .80 (Jeynes, 2007).

Science education allows for subject-specific parent involvement opportunities that other subjects may not offer, such as science clubs, museum field trips, after-school robotic programs, family science night events, and science research fairs. Furthermore, families can build their social and cultural capital through these parent involvement activities; thereby, benefitting their children. Through participation in local school boards or participating in policy development committees, parents can broaden their social networks and learn about academic standards and expectations, which may lead parents to partnering with school staff to help prioritize science learning and review science curricula. This insider's view of academic content and process would inform parents of the system their children are participants of.

Individual Differences

Science achievement differences based on race/ethnicity were evident in third grade, with White students outperforming Asian American, Hispanic and African American students. Science achievement rankings by race/ethnicity were similar to the National Assessment of Education Progress' science assessment results, with minority student scores lagging behind their White peers (National Center for Education Statistics, 2009). Achievement growth was more accelerated for Asian American students, but African American students had less of a decline in science achievement growth, compared to other ethnicities.

Hispanic and Asian American parents' school involvement was positively associated with students' science achievement growth, but not for African American or White students. Hong and Ho (2005) had similar findings where Asian American parents were involved in their adolescent students' school events, communicating with school personnel, and visiting the classroom, which had positive short- and long-term influences on their children's academic achievement. There is ample research about Hispanic families' lack of parent involvement, due to their beliefs about their role in their children's education, their perceptions of school expectations, and comfort with the English language (Chrispeels & Rivero, 2001; Huss-Keeler, 1997; Trueba, 1988). For these reasons and other risk factors, parent school involvement may be a protective factor for Hispanic families. African American students may be advantaged by their parents' school involvement, but not enough to overcome poor school quality. Reardon and Galindo (2009) found that African American and Hispanic students were similar in regards to socioeconomic backgrounds and cognitive skills at entry into kindergarten, but Hispanic students' narrowed the White-Hispanic gap in academic achievement by fifth grade; whereas, the White-Black achievement gap widened. Since SES and cognitive skills of Hispanic and Black students were similar a school entry, school quality may be the factor that influences science achievement in the present study.

The lack of a relationship between White students' science achievement and parent involvement is inconsistent with cultural and social capital theories. The students are from the dominant culture and thought to benefit from their parents' cultural and social capital. According to Bourdieu (1986), the cultural experience a student has at home is a resource that is transformed into cultural capital that can influence achievement positively or negatively.

Similarly, social capital is defined as “the resources developed through participation in social networks and the activation or magnification of those resources for social benefit” (Monkman, Ronald & Theramene, 2005, p.7). Cultural and social capital interact in the home and school to advantage some groups (dominant cultural and social groups) and disadvantage other groups (non-dominant cultural and social groups) in the school environment (Bourdieu, 1986). The present study measured a portion of the resources that families use to support their children, but did not measure other types of involvement, such as educational aspirations and home academic involvement that also play a significant role in cultural and social capital theories. Therefore, students from the dominant culture may benefit through high achievement from their parents’ cultural and social capital that occurs outside of the school and the school-related cultural and social capital may play a smaller part in students’ achievement. Yet, for minority families that may not have the same resources outside of school (less social and cultural capital), the school involvement activities may affect their achievement to a larger extent because of the extra boost it provides in the way of capital. Without additional “capital” outside of school, parent school involvement fills a dry reservoir for minority families, which advantages minority students through academic achievement.

An alternative view is to use household SES as a proxy for social status to test social and cultural capital, as has been done in previous research (see Lareau, 1987; Lee & Bowen, 2006; McNeal, 1999). SES was positively related to science achievement growth at each grade level studied; therefore, it is presumed that middle- to upper-class parents used their cultural and social capital to assist their children academically. A middle-class family understands how to communicate with school personnel in a comfortable and effective manner, volunteer at the school in a way that meets the expectations of the school and the importance of attending events at school; whereas a lower-class family may not have time, resources, and expertise to maneuver at ease in the school environment. Lareau's (2001) research reflects these findings, where working-class families' in her study confronted middle-class teachers and administration with different perceptions of parent involvement. Due to these competing ideas of a parent's role in a child's academic life, school personnel perceived working-class families as not caring about their children's academic future and as uninvolved, which was untrue. Hence, the resources and disposition that a higher SES parent has affects positively upon their child in their school environment.

Overall, the school system has standards that teachers and administrators use to evaluate students and parents, and families that are predisposed and aware of those standards are successful in the educational system (Lareau & Weininger, 2003). While the present study used cultural and social capital as a lens to examine differences in science achievement and longitudinal growth, partial support was gathered through a significant relationship between parent school involvement and eighth grade science achievement.

Limitations and Future Work

The present study has limitations in regards to measurement, generalizability, and lack of causality. First, the parent involvement variable was bounded by the questions on the survey, meaning there were other ways to measure parent involvement that the survey did not capture. Parent involvement is a multi-dimensional construct, but the present study focused on school-based involvement due to the limitation of choosing items that were the same at each time point. Second, the ECLS-K is a nationally representative sample, but it may only be generalizable to the 1998-1999 kindergarten cohort on which the study's sample was based. Although population characteristics were taken into account when the sample was chosen, those characteristics were based on one point in time and may not reflect the current national school, family and student populations. The last limitation concerns the observational nature of the data. Causal relationships between variables cannot be substantiated because extraneous variables were not controlled.

Conclusion

The aim of the present study was to use cultural and social capital theories to examine the developmental trajectory of science achievement from elementary to middle school and how parent involvement relates to growth, while exploring race/ethnicity group differences. Interindividual differences in science achievement growth factors are demonstrated by the present study, indicating some students are more at risk than others in deceleration of growth. Future research should investigate the negative association between initial status and rate of growth. Perhaps students that were gaining basic competency in science skills over time, but after basic competency was met, more complex problem-solving skills in scientific concepts were not necessarily achieved at a high rate, which may be a curriculum and instruction issue. Science curricula and instruction that emphasize reasoning skills, conceptual understanding, and skill application exceeds instructional practices that drill on skills and use worksheet practice activities that do not support higher-level cognitive skills. Although curriculum and instruction is out of the purview of this study, it may help to explain the negative relationship between initial science achievement status and growth.

Since one type of parent involvement was examined in the present study, more research should investigate other dimensions of parent involvement and its relation to science achievement growth across primary and secondary school. The investigation should differentiate by race/ethnicity and SES and any interactions thereof. The educational aspiration dimension of parent involvement has the strongest effect size of all other parent involvement dimensions as related to achievement, yet little research has examined science achievement specifically.

The implications of the present study on a substantive level point to the positive relationship between parent school involvement and science achievement in middle school. Parents that navigated the school system by attending school events and parent teacher groups, and fundraising and volunteering had children with increased science achievement at eighth grade. Differential effects of ethnic groups found that some minority groups benefitted from parent school involvement, but African Americans did not; suggesting quality of school settings may factor into academic achievement. Although White students had the highest level of science achievement at each time point, parent school involvement was not a significant predictor of achievement. This finding is inconsistent with cultural and social capital theories.

Implications at the theoretical level suggest there is value in exploring parental involvement and achievement through a cultural and social capital lens. Cultural and social capital theories suggest that White parent school involvement would significantly predict science achievement, but findings did not bear this out. The theories were defined by ethnicity and household SES, which may not best represent parents' cultural and social capital. There may be other effective measures of the theories; for example, parents' human capital, such as parents' cognitive abilities, may positively affect science achievement through cultural and social capital. In addition, parent involvement was narrowly restricted to the school, when capital at home and parents' beliefs may work together to predict achievement. These findings suggest that different forms of capital need to be examined in future research and how the forms may interact to influence academic achievement.

Focus was on examining developmental trajectory of science achievement with cultural and social capital theories, from third to eighth grade and its association with parent involvement. The emergence of eighth grade parent school involvement's positive relationship with eighth grade science achievement is significant because schools and parents can partner to influence achievement of students. Although there is more to understand about science achievement growth and different types of parent involvement, we added to cultural and social theory research on how students grow in their scientific knowledge and the importance of parent school involvement.

References

American Association for the Advancement of Science. (1998). *Blueprints for reform: Science, mathematics, and technology education.* New York: Oxford University Press.

Baldi, S., Jin, Y., Skemer, M., Green, P. J., & Herget, D. (2007). *Highlights from programme for international student assessment (PISA) 2006: Performance of U.S. 15-year-old students in science and mathematics literacy in an international context*. Washington, DC: U.S. Department of Education.

Bourdieu, P. (1986). The forms of capital. In J. Richardson (Ed.), *Handbook of theory and research for the sociology of education* (pp. 241 – 258). New York: Greenwood.

Browne, M. W., & Cudeck, R. (1993). Alternative ways of assessing model fit. In Bollen, K. A. & Long, J. S. (Eds.), *Testing structural equation models* (pp. 136–162). Beverly Hills, CA: Sage.

Carter, R. S., & Wojtkiewicz, R. A. (2000). Parental involvement with adolescents' education: Do daughters or sons get more help? *Adolescence*, *35*, 29-44. Retrieved from PubMed database (PMid: 10841295)

Chrispeels, J. H., & Rivero, E. (2001). Engaging Latino families for student success: How parent education can reshape parents' sense of place in the education of their children. *Peabody Journal of Education*, *76*, 119–169. doi:10.1207/S15327930pje7602_7

Coleman, J. S., & Hoffer, T. (1987). *Public and private high schools: The impact of communities*. New York: Basic Books.

Coleman, J. S. (1988). Social capital in the creation of human capital. *American Journal of Sociology*, *94*, S95-S120. doi:10.1086/228943

Colwell, S. C. (n.d.). *Chi-square difference testing using the Satorra-Bentler scaled chi-square.* Retrieved from http://www.uoguelph.ca/~scolwell/qmlinks.html

DiStefano, C., Zhu, M., & Mindrila, D. (2009). Understanding and using factor scores: Considerations for the applied researcher. *Practical Assessment, Research & Evaluation, 14*(20)*,* 1-11.

Domina, T. (2005). Leveling the home advantage: Assessing the effectiveness of parental involvement in elementary school. *Sociology of Education*, *78*, 233-249. doi:10.1177/003804070507800303

Duckworth, A. L., & Seligman, M. E. P. (2006). Self-discipline gives girls the edge: Gender in self-discipline, grades, and achievement test scores. *Journal of Educational Psychology*, *98*, 198-208. doi:10.1037/0022-0663.98.1.198

Duncan, T. E., Duncan, S. C., & Stryker, L. A. (2006). *An introduction to latent variable growth curve modeling: Concepts, issues, and applications* (2nd ed.). Mahwah, NJ: Lawrence Erlbaum Associates.

Duncan, G. J., & Magnuson, K. A. (2005). Can family socioeconomic resources account for racial and ethnic test score gaps? *The Future of Children*, *15*, 35-54. doi:10.1353/foc.2005.0004

Fan, X., & Chen, M. (2001). Parental involvement and students' academic achievement: A meta-analysis. *Educational Psychology Review*, *13*, 1-22. doi:10.1023/A:1009048817385

Feinstein, N. (2011). Diversity and equity in science education: Research, policy and practice. *Science Education, 95,* 571-573. doi: 10.1002/sce.20452

George, Y. S., Neale, D. S., Van Horne, V. V., & Malcolm, S. M. (2001). *In pursuit of a diverse science, technology, engineering and mathematics workforce*. Retrieved from American Association for the Advancement of Science website: http://ehrweb.aaas.org/mge/Reports/Report1/AGEP/AGEP_report.pdf

Gorad, S. & See, B. H. (2009). The impact of socio-economic status on participation and achievement in science. *Studies in Science Achievement, 45,* 93-129. doi: 10.1080/03057260802681821v

Greenfield, T. A. (1996). Gender, ethnicity, science achievement, and attitudes. *Journal of Research in Science Teaching*, *33*, 901-933.

Guiso, L., Monte, F., Sapienza, P., & Zingales, L. (2008). Diversity: Culture, gender, and math. *Science*, *320*, 1164. doi:10.1126/science.1154094

Hahs-Vaughn, D.L. (2005). A primer for using and understanding weights with national datasets. *The Journal of Experimental Education*, *73*, 221-248. doi:10.3200/JEXE.73.3.221-248

Hair, J. E., Anderson, R. E., Tatham, R. L., & Black W. C. (1998). *Multivariate data analysis*. (5th ed.). Upper Saddle River, NJ: Prentice-Hall.

Harris, A. & Goodall, J. (2008). Do parents know they matter? Engaging all parents in learning. *Educational Research, 50,* 277- 289. doi:10.1080/00131880802309424

Haworth, C. M., Dale, P. S., & Plomin, R. (2009). The etiology of science performance: Decreasing heritability and increasing importance of the shared environment from 9 to 12 years of age. *Child Development, 80,* 662-673. doi: 10.1111/i.1467-8624.2009.01289.x

Hill, N. E., & Tyson, D. F. (2009). Parental involvement in middle school: A meta-analytic assessment of the strategies that promote achievement. *Developmental Psychology*, *45*, 740. doi:10.1037/a0015362

Honaker, J., King, G., & Blackwell, M. 2009. A*melia II: A program for missing data.* Retrieved from http://gking.harvard.edu/amelia/

Hong, S., & Ho, H. Z. (2005). Direct and indirect longitudinal effects of parental involvement on student achievement: Second-order latent growth modeling across ethnic groups. *Journal of Educational Psychology*, *97*, 32-42. doi:10.1037/0022-0663.97.1.32

Horn, L. & Kojaku, L. K. (2001). High school academic curriculum and the persistence path through college: Persistence and transfer behavior of undergraduates 3 years after entering 4-year institutions. *NCES Quarterly*, 3, retrieved from: http://nces.ed.gov/programs/quarterly/vol_3/3_3/q4-1.asp

Hu, L.T., & Bentler, P. (1995). Evaluating model fit. In R. H. Hoyle (Ed.), *Structural equation modeling: Concepts, issues, and applications* (pp.76-99). London: Sage.

Huss-Keeler, R. L., (1997). Teacher perception of ethnic and linguistic minority parental involvement and its relationships to children's language and literacy learning: A case study. *Teaching and Teacher Education*, *13*, 171-172. doi:10.1016/S0742-051X(96)00018-2

Jacobs, J. E. (2005). Twenty-five years of research on gender and ethnic differences in math and science career choices: What have we learned? *New Directions for Child and Adolescent Development*, *110*, 85-94. doi:10.1002/cd.151

Jeynes, W. H. (2005). A meta-analysis of the relation of parental involvement to urban elementary school student academic achievement. *Urban Education*, *40*, 237-269. doi:10.1177/0042085905274540

Jeynes, W. H. (2007). The relationship between parental involvement and urban secondary school student academic achievement. *Urban Education*, *42*, 82-110. doi:10.1177/0042085906293818

Joreskog, K., & Sorbom, D. (2009). *Lisrel 8.80 Student Edition*. Lincolnwood, IL: Scientific Software International, Inc.

Lareau, A. (1987). Social class differences in family-school relationships: The importance of cultural capital. *Sociology of Education*, *60*, 73-85. doi:10.2307/2112583

Lareau, A. (2001). Embedding capital in a broader context: The case of family-school relationships. In B. Biddle (Eds.), *Social class, poverty, and education* (pp. 77 – 100). London: Routledge Falmer.

Lareau, A., & Weininger, E. B. (2003). Cultural capital in educational research: A critical assessment. *Theory and Society*, *32*, 567-606. doi:10.1023/B:RYSO.0000004951.04408.b0

Leahy, E., & Guo, G. (2001). Gender differences in mathematical trajectories. *Social Forces*, *80*, 713-732. doi:10.1353/sof.2001.0102

Lee, J., & Bowen, N. (2006). Parent involvement, cultural capital, and the achievement gap among elementary school children. *American Educational Research Journal*, *43*, 193-218. doi:10.3102/00028312043002193

Lee, V. E., & Burkam, D. T. (1996). Gender differences in middle grade science achievement: Subject domain, ability level, and course emphasis. *Science Education*, *80*, 613-650.

Levine, D. U., & Eubanks, E. E. (1990). Achievement disparities between minority and nonminority students in suburban schools. *The Journal of Negro Education*, *59*, 186-194. doi:10.2307/2295644

Levine, P. B., & Zimmerman, D. J. (1995). The benefit of additional high-school math and science classes for young men and women. *Journal of Business & Economic Statistics*, *13*, 137-49. doi:10.2307/1392368

LoGerfo, L., Nichols, A., & Chaplin, D. (2006). Gender gaps in math and reading gains during elementary and high school by race and ethnicity. Retrieved from Urban Institute website: http://www.urban.org/url.cfm?ID=411428

Ma, X. & Wilkins, J. L. (2002). The development of science achievement in middle and high school: Individual differences and school effects. *Evaluation Review, 26,* 395-417.

Monkman, K., Ronald, M., & Theramene, F. D. (2005). Social and cultural capital in an urban Latino school community. *Urban Education*, *40*, 4-33. doi:10.1177/0042085904270416

McNeal, R. B. (1999). Parental involvement as social capital: Differential effectiveness on science achievement, truancy, and dropping out. *Social Forces*, *78*, 117-144. doi:10.2307/3005792

Millar, R. (2008). Scientific literacy and its implications as a curriculum aim. In S. Mikelskis-Seifert, U. Ringelband & M. Bruckmann (Eds.), *Four decades of research in science education: From curriculum development to quality improvement* (pp. 43-56). Münster, Germany: Waxmann Verlag GmbH.

Muthén, L. K., & Muthén, B. O. (2010). Mplus: Statistical analysis with latent variables - User's guide (6th ed.). Retrieved from http://www.statmodel.com

National Center for Education Statistics (2006). *The nation's report card: Science 2005* (NCES 2006466). National Center for Education Statistics, Institute of Education Sciences, U.S. Department of Education, Washington, D.C.

Newkirk, T. (2002). *Misreading masculinity: Boys, literacy, and popular culture.* Portsmouth, NH: Heinemann.

No Child Left Behind Act of 2001: Qualifications for Teachers and Professionals, 20 U.S.C. § 6319 (2008).

Parsons, E. C. (2008). Learning context, black cultural ethos, and the science achievement of African American students in an urban middle school. *Journal of Research in Science Education, 45,* 665-683. doi: 10.1002/tea.20240

Reardon, S. F., & Galindo, C. (2009). The Hispanic-white achievement gap in math and reading in the elementary grades. *American Educational Research Journal*, *46*, 853-891. doi:10.3102/0002831209333184

Rutherford, F. J. & Ahlgren, A. (1991). *Science for all Americans.* (2nd ed.). New York: Oxford University Press.

Satorra, A., & Bentler, P. (1999). *A Scaled Difference Chi-square Test Statistic for Moment Structure Analysis*. Retrieved from http://preprints.stat.ucla.edu/260/chisquare.pdf

Sirin, S. R. (2005). Socioeconomic status and academic achievement: A meta-analytic review of research. *Review of Educational Research*, *75*, 417-453. doi:10.3102/00346543075003417

Smith, F. M., & Hausafus, C. O. (1998). Relationship of family support and ethnic minority students' achievement in science and mathematics. *Science Education*, *82*, 111-125. doi:10.1002/(SICI)1098-237X(199801)

Starkey, P., & Klein, A. (2008). Sociocultural influences on young children's mathematical knowledge. In O. N. Saracho & B. Spodek (Series Eds.), *Contemporary perspectives in early childhood education: Mathematics in early childhood education* (pp. 253-276). Greenwich, CT: Information Age Publishing.

Tourangeau, K., Lê, T., Nord, C., & Sorongon, A. G. (2009). *Early Childhood Longitudinal Study, Kindergarten Class of 1998–99 (ECLS-K), eighth-grade methodology report* (NCES 2009–003). Washington, DC: National Center for Education Statistics, Institute of Education

Sciences, U.S. Department of Education. Retrieved from http://nces.ed.gov/pubsearch/pubsinfo.asp?pubid=2009003

Trueba, H. T. (1988). Peer Socialization among Minority Students: A High School Dropout Prevention Program. In H. T. Trueba & C. Delgado-Gaitan (Eds.) *School and society: Learning content through culture* (pp. 201-217). New York: Praeger.

Zimosky, M.F., Muraki, E., Mislevy, R.J., & Bock, R.D. (2007). *BILOG-MG-3*. Chicago: Scientific Software, Inc.

Table 1

Descriptive Statistics and Correlations among Variables for the Full Sample

	Public	Suburb	Rural	Free Lunch	SES, 3rd	SES, 5th	SES, 8th	PI, 3rd	PI, 5th	PI, 8th	Science, 3rd	Science, 5th	Science, 8th
Public	1.118 (0.329)												
Suburb	-.030**	0.219 (0.422)											
Rural	-.083**	-.461**	0.437 (0.498)										
Free Lunch	-.356**	.020**	-.265**	33.661 (28.700)									
SES, 3rd	.239**	-.093**	.170**	-.528**	-0.073 (0.809)								
SES, 5th	.247**	-.093**	.177**	-.528**	.943**	-0.051 (0.806)							
SES, 8th	.245**	-.094**	.160**	-.511**	.908**	.936**	-0.108 (0.796)						
PI, 3rd	.107**	-.042**	.076**	-.163**	.214**	.215**	.215**	-0.052 (0.416)					
PI, 5th	.118**	-.009**	.064**	-.169**	.219**	.221**	.218**	0.673	-0.043 (0.429)				
PI, 8th	.110**	-.030**	.040**	-.107**	.169**	.172**	.176**	0.556	0.579	-0.033 (0.448)			
Science, 3rd	.141**	.018**	.111	-.438**	.499**	.489**	.484**	.120**	.124**	.081**	50.234 (15.561)		
Science, 5th	.151**	-.005**	.105	-.425**	.492**	.486**	.475**	.128**	.136**	.091**	.847**	64.063 (15.837)	
Science, 8th	.155**	-.035**	.112**	-.432**	.488**	.481**	.469**	.142**	.131**	.103**	.757**	0.804	82.585 (16.872)

Note. Numbers on the diagonal refer to the mean and standard deviation (in parentheses). Public = school type; suburb = school location dummy coded for suburban area or large town; rural = small town and rural area; free lunch = % of free lunch eligible students in each school; SES, 3rd, 5th, and 8th = parents' socioeconomic status at 3rd, 5th, and 8th grades, respectively; PI, 3rd, 5th, 8th = parent school involvement at 3rd, 5th, and 8th grades, respectively; science 3rd, 5th, and 8th = student science achievement scores at 3rd, 5th, and 8th grades, respectively.

** $p \leq .01$. All tests were two-tailed.

Table 2

Science Achievement: Summary of Goodness of Fit for All Models

Model	χ^2	*df*	AIC	CFI	TLI	RMSEA	CI (90)	Description
Full Sample								
1	38.841	1	184256.201	.994	.982	.068	.051-.088	Unconditional Linear Model[a]
2	41.172	5	280700.795	.994	.983	.032	.024-.041	Conditional with School-level Variables
3	194.352	11	300097.737	.974	.944	.045	.040-.051	Conditional Model with School-level Variables and SES
4	205.201	33	318607.015	.975	.951	.037	.033-.042	Conditional Model with School-level Variables, SES, and Parent Involvement[a]
Multiple-group tests: Invariance across race/ethnicity								
5a	308.135	68	310979.448	.972	.946	.042	.037-.047	No constraints[a]
5b	323.651	74	311066.102	.971	.948	.041	.036-.046	Intercept and Slopes constrained
5c	349.493	77	311057.095	.968	.945	.042	.037-.046	Variances and Covariances constrained

Note. AIC = Akaike Information Criterion; CFI = comparative fit index; TLI = Tucker-Lewis index; RMSEA: root mean square error of approximation; CI (90) = 90% confidence interval of RMSEA.

[a] Model selected.

Table 3

Unstandardized Estimates for Growth Curve Models of Science Achievement

	Unconditional Model	Conditional Models[a]		
	Model 1	Model 2	Model 3	Model 4
Means				
Intercept	50.486 (.291) ***	58.756 (1.262)***	57.348 (1.167)***	57.370 (1.167)***
Linear Slope	6.478 (.042)***	6.687 (.197)***	6.780 (.205)***	6.803 (.206)***
Variances				
Intercept	215.028 (6.026)***	171.586 (5.540)***	150.026 (5.598)***	149.961 (5.606)***
Linear Slope	2.203 (.393)***	2.476 (.361)***	2.726 (.336)***	2.719 (.336)***
Covariances				
Intercept and Linear Slope	-3.216 (1.015)**	-4.418 (.936)***	-4.896 (.882)***	-4.883 .879)***
Predicting Intercept				
School Type		-.574 (.776)	-1.287 (.731)	-1.034 (.732)
Suburban School		1.063 (.702)	1.810 (.664)**	1.809 (.664)**
Rural School		.176 (.705)	.118 (.660)	.109 (.659)
% Free Lunch		-.237 (.009)***	-.166 (.010)***	-.166 (.010)***
Predicting Linear Slope				
School Type		.098 (.119)	.067 (.123)	.051 (.123)
Suburban School		-.515 (.125)***	-.513 (.129)***	-.513 (.129)***
Rural School		-.191 (.100)	-.185 (.102)	-.187 (.102)
% Free Lunch		-.004 (.002)*	-.004 (.002)*	-.004 (.002)*
Predicting Science Achievement				
SES at 3rd grade			5.043 (.344)***	5.037 (.347)***
SES at 5th grade			4.714 (.340)***	4.667 (.341)***
SES at 8th grade			5.059 (.391)***	4.993 (.393)***
Parent Involvement at 3rd grade				.217 (.388)
Parent Involvement at 5th grade				.569 (.369)
Parent Involvement at 8th grade				.913 (.450)*

Note. [a] In the conditional models, means are intercepts and variances are residual variances. Standard errors are in parentheses.

* $p \leq .05$. ** $p \leq .01$. *** $p \leq .001$.

Table 4

Race/Ethnicity Multiple-Group Analysis: Unstandardized Estimates for Growth Curve Models of Science Achievement

	African American	Asian American	Hispanic	White
n	704	429	1,717	5,219
χ^2	48.345	28.068	91.508	140.214
df	68	68	68	68
p-value	<.001	<.001	<.001	<.001
Means				
Intercept	49.128 (3.444)***	55.901 (2.909)***	53.511 (2.255)***	59.464 (1.543)***
Linear Slope	6.307 (.843)***	6.507 (.564)***	7.189 (.459)***	6.654 (.227)***
Variances				
Intercept	129.793 (14.122)***	119.078 (14.993)***	144.656 (8.568)***	145.961 (8.241)***
Linear Slope	6.307 (.843)***	1.960 (.861)***	4.697 (.645)***	1.690 (.417)***
Covariances				
Intercept and Linear Slope	-2.150 (2.456)***	-3.463 (2.019)***	-5.359 (1.478)***	-5.548 (1.170)***
Predicting Intercept				
School Type	-2.185 (2.572)	1.664 (1.715)	-1.180 (1.459)	-1.198 (.898)
Suburban School	-.811 (1.769)	-5.140 (1.796)**	2.411 (1.808)	.061 (.899)
Rural School	-.150 (1.969)	.082 (2.197)	1.122 (.896)	-1.385 (.774)
% Free Lunch	-.080 (.021)***	-.197 (.025)***	-.130 (.016)***	-.114 (.019)***
Predicting Linear Slope				
School Type	.216 (.617)	.232 (.327)	.073 (.308)	.047 (.131)
Suburban School	-.327 (.405)	-.214 (.298)	-1.173 (.477)**	-.267 (.149)
Rural School	.059 (.279)	-.503 (.336)	-.130 (.183)	-.111 (.128)
% Free Lunch	-.008 (.005)	.003 (.005)	-0.003 (.004)	-.005 (.003)
Predicting Science Achievement				
SES at 3rd grade	3.450 (.898)***	2.007 (.997)*	5.413 (.632)***	4.604 (.473)***
SES at 5th grade	3.581 (.878)***	3.178 (1.000)**	4.266 (.621)***	4.410 (.462)***
SES at 8th grade	5.026 (1.064)***	5.274 (1.085)***	4.161 (.727)***	4.756 (.517)***
Parent Involvement at 3rd grade	-.584 (.944)	2.663 (1.171)*	.743 (.598)	-.019 (.533)
Parent Involvement at 5th grade	1.345 (1.111)	1.235 (1.259)	1.515 (.589)**	-.234 (.477)
Parent Involvement at 8th grade	1.482 (1.325)	-2.235 (1.364)	1.642 (.787)*	.398 (.556)

Note. Means are intercepts and variances are residual variances. Standard errors are in parentheses.
* $p \leq .05$. ** $p \leq .01$. *** $p \leq .001$.

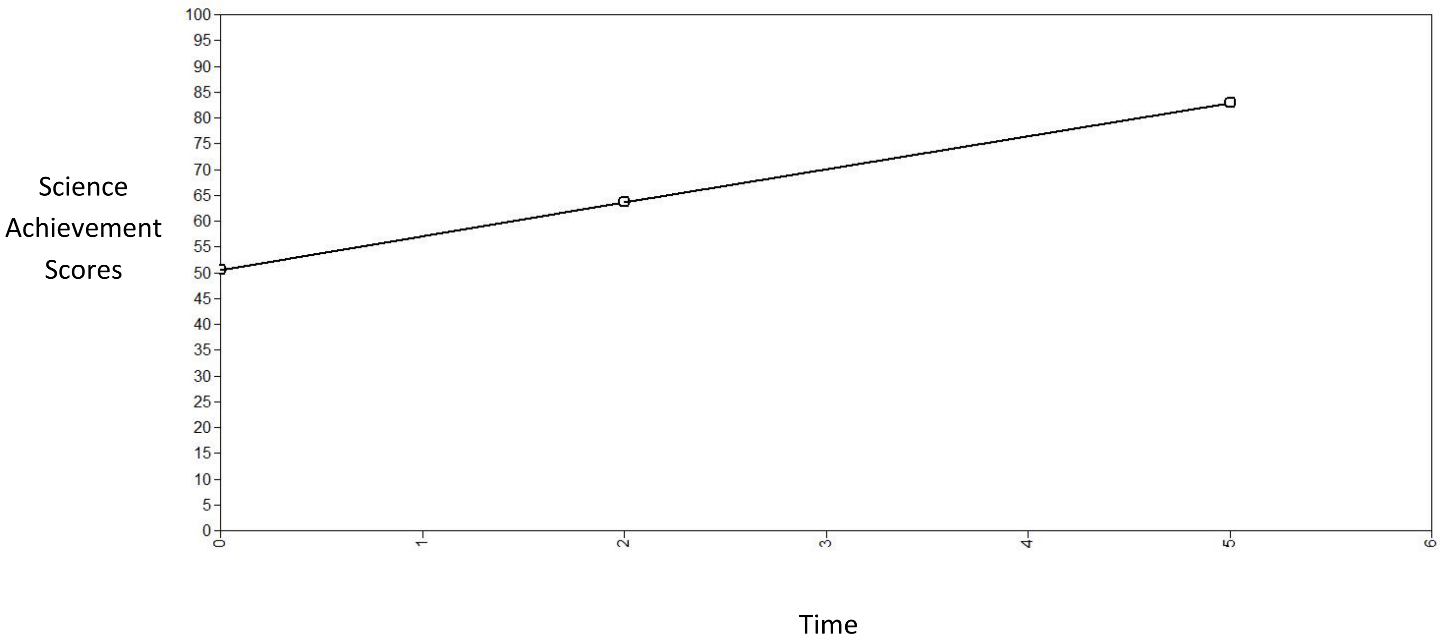

Figure 1. Plot of the science achievement means without covariates. The x-axis is the time point of each measurement occasion (0 = 3rd, 2 = 5th, 5 = 8th) and the y-axis is the science achievement IRT scores. The solid line is the linear trajectory of the full sample.

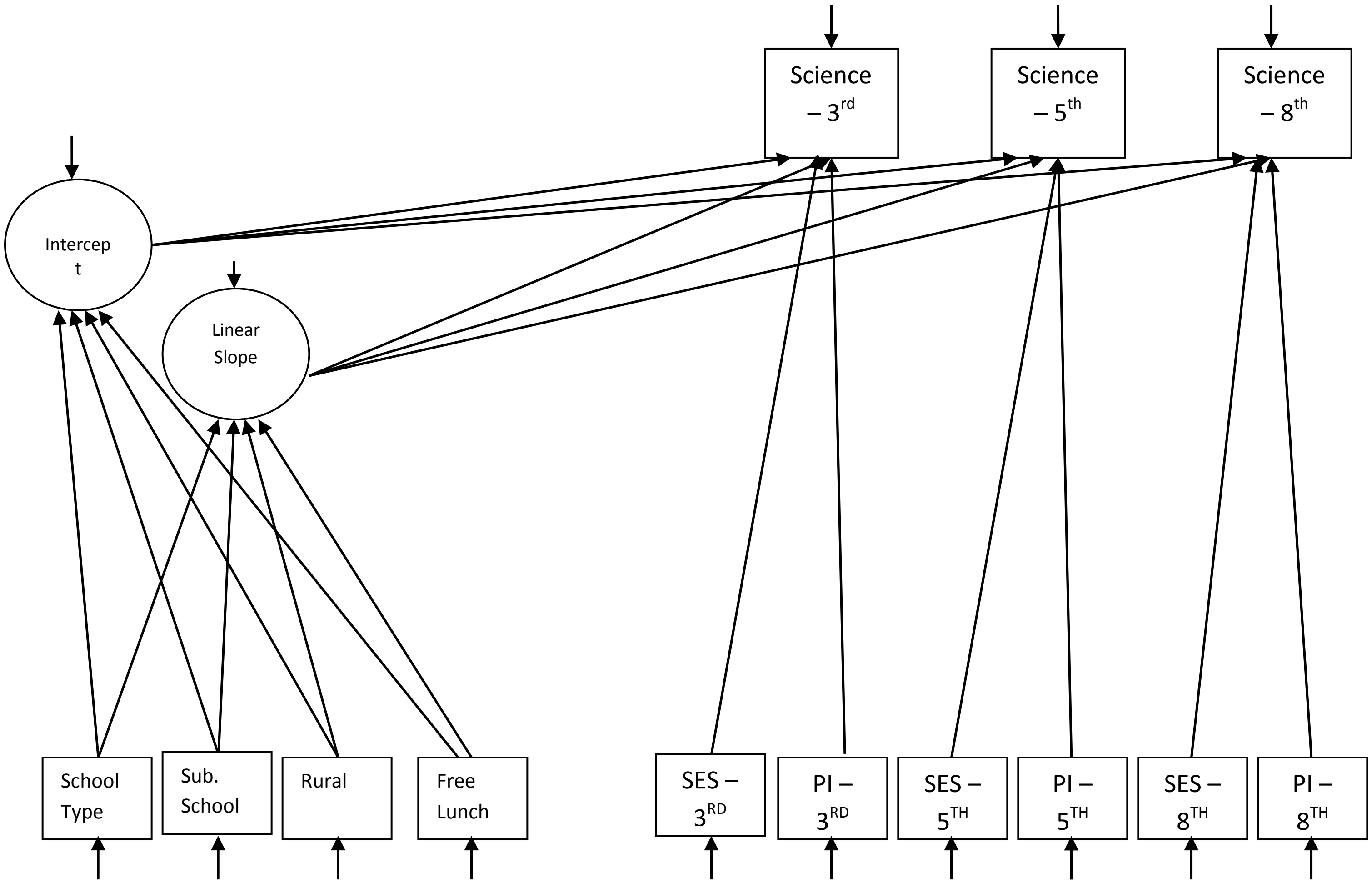

Figure 2. Conditional latent growth curve model of science achievement with covariates. Science – 3rd through 8th = science item response theory scores in springs of 3rd grade, 5th grade, and 8th grade, respectively; SES – 3rd through 8th and PI – 3rd through 8th = socioeconomic status and parent involvement at 3rd grade, 5th grade, and 8th grade; School type = public/private school at third grade; Sub. School = attendance in suburban school at third grade; Rural = attendance in rural school at third grade; Free Lunch = percentage free lunch eligible students at school in third grade.

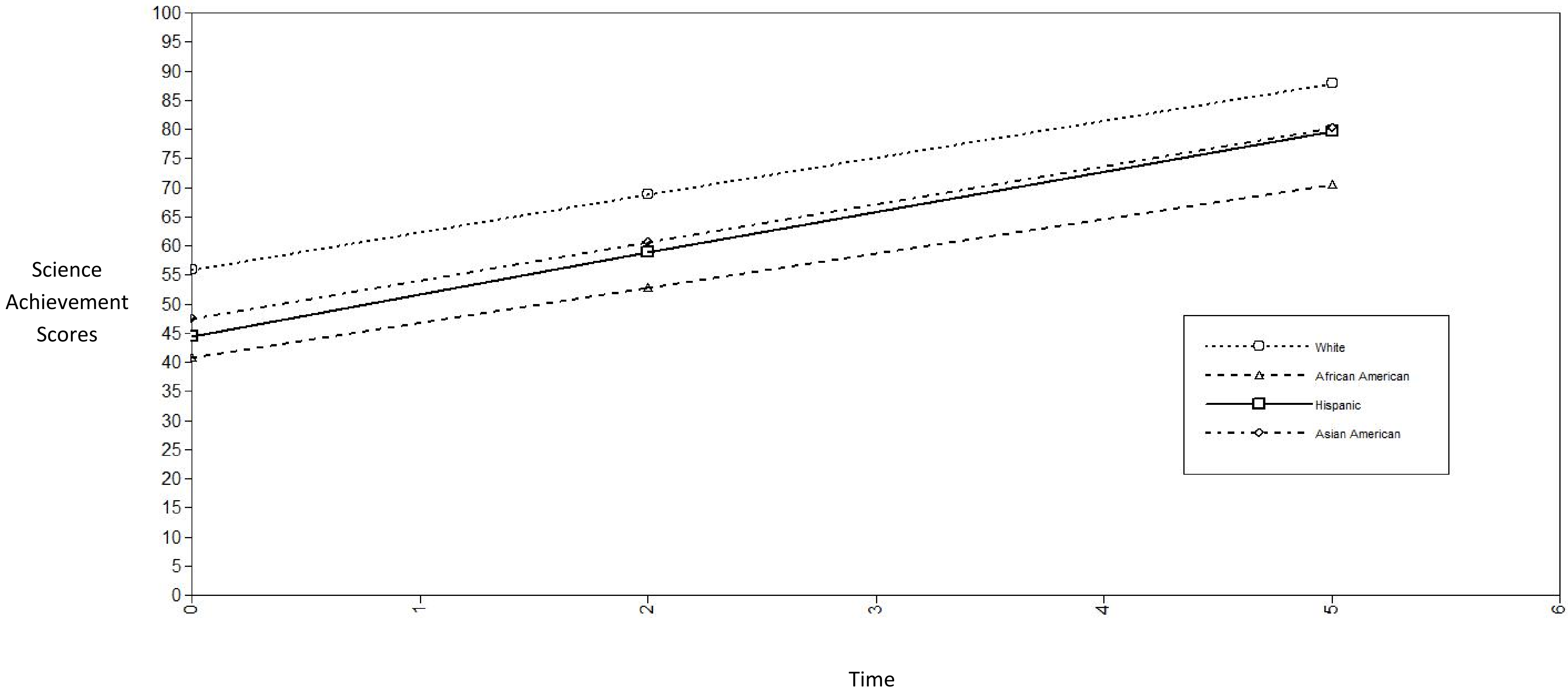

Figure 3. Plot of the science achievement means by race/ethnicity. The x-axis is the time point of each measurement occasion (0 = 3rd, 2 = 5th, 5 = 8th) and the y-axis is the science achievement IRT scores, disaggregated by race/ethnicity. The four lines represent the linear trajectory of science achievement for the White sub-sample (dotted line with circles), Asian American sub-sample (dash-dot-dash and diamonds), Hispanic sub-sample (solid line and squares), and African-American sub-sample (dashed line and triangles) across elementary and middle schools.

APPENDIX A

EXTENDED LITERATURE REVIEW

Conceptual Framework

When the persistent achievement gap is looked at through the lens of cultural and social capital, it can be summed up as "students with more valuable social and cultural capital fare better in school than do their otherwise-comparable peers with less valuable social and cultural capital" (Lareau & Horvat, 1999, p. 37). Therefore, there may be social and cultural factors that lead to certain groups of students that are advantaged educationally. One of the processes by which this happens may be parent involvement in educational activities in home and/or at school. There are various forms of capital that are related to positive development of human capital, or the knowledge, skills, and attributes that lead to productivity, such as economic capital, informational capital, and physical capital, but focus has been on social and cultural capital in the last 40 years of sociological research and how it mediates human capital in reproducing social inequality in the educational system. Monkman, Ronald, and Theramene (2005) explain that "(t)he various forms of capital tend to reflect and reproduce stratification patterns in a class-based society such as the United States" (p. 7), and as such, "(s)ocial and cultural capital reflect social relationships, cultural practices, and knowledge that are used to gain social and economic benefit" (p. 7). In the context of education, the social and economic benefit can be interpreted as student achievement that is mediated by the cultural and social capital of students' family, e.g., parent involvement.

Cultural and Social Capital: Reproduction of Inequities in the Educational System

The French sociologist, Pierre Bourdieu, is perhaps best known for development of his conceptual model of social reproduction that addresses the notion that disparities in student achievement cannot be explained by economic reasons alone, but that students of different social classes attain different levels of achievement due to cultural and social capital. Since "the culture of the dominant class is transmitted and rewarded by the educational system" (Dumais, 2002, p. 44), social inequities are reproduced in the educational system. According to Bourdieu (1986), the cultural experience a student has at home is a resource that is transformed into cultural capital that can influence achievement positively or negatively. Similarly, social capital is defined as "the resources developed through participation in social networks and the activation or magnification of those resources for social benefit" (Monkman et al, 2005, p.7). Cultural capital and social capital interact in the home and school to advantage some groups (dominant cultural and social groups) and disadvantage other groups (non-dominant cultural and social groups) in the school environment (Bourdieu, 1986).

James S. Coleman, an American sociologist renowned for the "Coleman Report" (1966), which addressed racial integration in schools and school busing that informed public policy, also researched and developed his own concept of social capital. Coleman (1987) believed social capital played an important role in human capital because "the norms, the social networks, and the relationships between adults and children" (p. 36) influences the academic achievement of students. While Coleman's concept of social capital is similar to Bourdieu's, it differs based on Coleman's uncritical analysis of the education system's power structure and its impact on parent-school relations and possibly students' achievement.

Cultural and social capital work together to reproduce the structure of power relationships between social classes and it is played out in schools (Bourdieu, 1977) because familial cultural resources are "activated and transformed into cultural capital…(and) transmitted via social networks when social capital is activated" (Monkman et al., 2005, p. 26).

Social Reproduction Model: Habitus and Field

While cultural capital is a significant, and often-cited, concept of Bourdieu's model, it is only one piece. Therefore, we will examine his three key elements, habitus, field, and capital, before cultural capital is explained in detail. In one word habitus is a person's disposition, a way of thinking about one's place in the world, characterized by past experiences, tastes, and sensibilities learned at a young age through a person's upbringing (Dumais, 2002). Habitus is important to the concept of cultural capital because cultural capital can be derived from an individual's habitus. The habitus of a person informs how she perceives herself in relation to others and how she behaves. According to Grenfell and James (1998), habitus forges a "strong sense of the embodiment of social and cultural messages…including how people carry themselves as well as the (slightly) metaphorical carrying of thoughts and feelings" (p.14). When the habitus of the individual closely reflects the habitus of society there is no conflict, but when society's habitus and an individual's habitus clash then differences are felt. Lareau (2001) provides the example of working-class families' habitus confronting the habitus of middle-class teachers. There will probably be disagreements and at the very least "(f)amilies, particularly working-class families, can feel the "weight" of the differences of the dispositions" (Lareau, 2001, p 85). Bourdieu does not believe that if a person is born at a certain station in life, they will remain so because a person can be upwardly mobile and learn how to behave and "fit in," but the ease and naturalness that a person has in the higher social class will never equal the ease and naturalness of a person that was born into that class (Lareau, 2001).

Habitus is not limited to thoughts and feelings, but can lead to action by externalizing beliefs into behavior, such as the belief that since one is born into a certain social class; they will remain in that social class and will behave as such (Dumais, 2002). The actions or behaviors of a person happen in a field. Broadly defined, the field is “a structured system of social relations at a macro and micro level” (Grenfell & James, 1998, p.16). There are different types of fields where an individual’s habitus and capital interacts with the rules of the field. For example, the K – 12 school system is considered a field. This field consists of the U. S. Department of Education, state education agencies, independent school districts, local school boards, and local schools. Also, there would be belief systems, values, and rules of the field that guides curriculum decisions, academic standards, relationships among the Secretary of Education, governors, school board members, superintendents, principals, teachers, parents, and students, relationship between family and school, academic success, and the meaning and value of the K – 12 education. Overall, “fields are spaces in which dominant and subordinate groups struggle for control over resources; each field is related to one or more types of capital” (Dumais, 2002, p. 46), such as economic, social and cultural capital.

Social Reproduction Model: Cultural Capital

According to Bourdieu (1986), capital can be divided into three different concepts: a) economic capital, which is authority over cash and/or assets, b) social capital, which are resources based on memberships, networks, and connections that provide support, and c) cultural capital, the skills, education, attitude and knowledge that can be advantageous for an individual and can be transmitted from parents to children. Focus is on cultural capital because of its strong relationship with the educational system and students’ success or lack thereof.

Through Bourdieu’s (1977) seminal work on social and cultural reproduction “(t)he concept of “capital” has enabled researchers to view culture as a resource – one that provides access to scarce rewards, is subject to monopolization, and under certain circumstances, may be transmitted from one generation to the next" (Lareau & Weininger, 2003, p. 567). Cultural capital is further partitioned into three forms: objectified, institutionalized, and embodied. A connection to objects is classified as objectified cultural capital, such as works of art, books, electronics, and dictionaries (Bourdieu, 1986; Dumais, 2003; Grenfell & James, 1998). Institutionalized cultural capital is connected to institutions and educational credentials, such as schools and universities and diplomas and degrees. Embodied cultural capital is in the form of general character to understand cultural commodities. In sum, "(i)nstitutionalized cultural capital develops as a result of one's having embodied cultural capital and successfully converting it via the educational system. To appropriate and use objectified cultural capital, one needs embodied cultural capital" (Dumais, 2002, p.46). Thus, students enter the educational field with varying levels of cultural capital and habitus formed in them by their upbringing and family's social capital, which will impact their success in school.

While the concept of cultural capital is abundant in educational research literature, the manuscripts can be divided into two camps of thought: a) cultural capital is a latent factor that can be indirectly measured by manifest variables, such as participation in activities thought to be reserved for high socioeconomic individuals, (DiMaggio, 1982; Dumais, 2002; Kalmijn & Kraaykamp, 1996) and b) families have different cultural resources and use this cultural capital to navigate through the educational system that has arbitrary standards (Lareau, 1987; Lareau, 2001; Lareau, & Horvat, 1999; Lareau & Weininger, 2003). In the former, conceptualization of cultural capital is "in terms of prestigious, "highbrow" aesthetic pursuits and attitudes, and an insistence that it can be conceptually and causally distinguished from the effects of "ability"

(Lareau & Weininger, 2003, p. 575). Researchers in this camp unequivocally accept that institutional standards are legitimate and investigate how parents and students need to meet those standards. In the latter camp, researchers have "a clear focus on the standards that educators use to evaluate students or their parents…these works do not uncritically accept given institutional standards as legitimate, and then seek methods for boosting parents' and students' compliance with them…(i)nstead, they examine the ways in which cultural resources help families comply with these standards" (italics in original, Lareau & Weininger, 2003, p. 586). Similarly to the latter group, this present study uses cultural capital as a lens to examine differences in group math and science achievement and longitudinal growth; and acknowledges that the standards for achievement and growth may conflict with the habitus and cultural resources of some groups.

Previous Research on Cultural Capital

Lareau (1987) investigated family-school relationships, specifically, parent involvement in their child's educational life, using cultural capital as a way to understand family school experiences based on social class. Her qualitative study used interviews of parents, teachers, and principals and observations of two first grade classrooms, one classroom in a White working-class community and the other a White middle-class community. Lareau found that teachers and principals in both schools had a standardized view of parental involvement, which included parents and teachers being partners in their child's education, volunteering in the school or classroom, formal and informal contact with teacher about child's academic progress that reflected middle-class values, and similar values of teachers and principals at both schools. When there was dissonance between institutional standards over parent involvement, working-class parents were judged as not valuing education, which was untrue (Lareau, 1987). Parents in both communities wanted the best academically for their children, but due to their habitus and cultural capital, their behaviors differed, such as the following:

> In the working-class community, parents turned over the responsibility for education to the teacher. Just as they depended on doctors to heal their children, they depended on teachers to educate them. In the middle-class community, however, parents saw education as a shared enterprise and scrutinized, monitored, and supplemented the school experience of their children (p. 81).

Lareau's study resulted in parents with low socioeconomic status demonstrated low parental involvement (as defined by the school), while parents of high socioeconomic status were perceived as having high parental involvement, which exemplifies Bourdieu's idea of cultural concept; that position in social class and cultural resources form a cultural capital in the field of school.

To further clarify the concept of cultural capital, parent involvement and the school setting, two studies are briefly reviewed next. Lareau and Weininger's (2003) qualitative study of a middle-income African American family and a low-income African American family interacting with school staff resulted in description of how the middle-income family was better able to comply with the school's standard of active parent involvement; therefore, the mother was judged highly on her parental involvement. Lareau and Weininger posited that the school's standards highly valued the parenting skills of one group, while devaluing other parenting skills; at the same time not acknowledging that all parents across groups are not knowledgeable in the highly valued style of parenting. Therefore, "individuals' strategic use of knowledge, skills, and competence come into contact with institutionalized standards of evaluation" (Lareau & Weininger, 2003, p. 597) with some families winning and losing based on their cultural capital.

Lee and Bowen (2006) examined five different types of parent involvement on third through fifth graders academic achievement and found that teacher's reported higher achievement of students' with parents in dominant groups, i.e., White, educated, and not poor. Though Bourdieu's cultural capital concept was supported by the findings, only partially so because all students benefitted from varying types of parent involvement. White parents were more involved at school and less involved in time management. Black and Latino parents were less involved in school, but more involved in time management activities in home, compared to White parents. In sum, while Lareau (1987) and Lareau and Weininger (2003) show that Bourdieu's concept of cultural capital works as a framework to examine how parent involvement and the school interacts to impede or facilitate family-school relations and possibly student achievement, Lee and Bowen (2006) found only partial support. Coleman's theory of social capital explained the remainder of Lee and Bowen's findings, which is discussed more below.

Social Capital

The concept of social capital is not a new one. Sociologists, from Emile Durkheim to Karl Marx, have purported that group membership and participation benefits, individuals and the community at-large. Boudieu built upon that work and defined social capital as the "aggregate of the actual or potential resources which are linked to possession of a durable network of more or less institutionalized relationships of mutual acquaintance and recognition – or in other words, to membership in a group – which provides each of its members with the backing of the collectively-owned capital, a "credential" which entitles them to credit, in the various senses of the word" (Bourdieu, 1986, p. 248-249). He focused on how an individual's social network acts as a resource, or capital, for the individual and the number and value of these resources can be transformed to other capital, such as economic or human capital. For example, through social capital, parents can benefit their children by accessing additional economic capital, such as a scholarship or increase their cultural capital through membership in a PTA/PTO or a parenting class.

Simply, social capital is for the benefit of creating human capital, according to Coleman and Hoffer (1987; Coleman, 1988). Coleman's definition of social capital parallels Bourdieu's, in that individuals use their networks for their own interests. Coleman and Hoffer (1987) explicitly stated that parents are strongly affected by the human capital possessed by their parents.

But this human capital can be irrelevant to outcomes for children if parents are not an important part of their children's lives, if their human capital is employed exclusively at work or elsewhere outside the home….That is, if the human capital possessed by parents is not complemented by social capital embodied in family relations, it is irrelevant to the child's educational growth that the parent has a great deal, or a small amount, of human capital (p. 223).

Therefore, Coleman finds a positive relationship between parents' educational involvement (social capital) and children's school outcomes (human capital). Because of this relationship, Coleman believes that parents should adopt certain practices, such as building and maintaining relationships with schools, to increase student achievement. This is where Bourdieu and Coleman diverge in their concepts of social capital. While Coleman advocates for families to adopt the institutional standards and values of the school, which are similar to the dominant group's, Bourdieu does not because from the outset, Bourdieu views the standards as arbitrary and part of the unequal power and structure of the educational institution (Lareau, 2001).

Coleman and Bourdieu both define social capital as an intangible resource found among the relations of individuals and through membership in various networks. Portes (1998) maps out positive and negative consequences to securing social resources. Positive consequences include social control, family support and network mediated benefits. Social control takes on the form of informal rule enforcement in the family and community rendering formal sanctions unnecessary, such as when parents and teachers work together to handle a physical disagreement between students, rather than reporting it to the police resulting in a possible assault charge. Families where one parent accepts responsibility for most of the child rearing offer more social capital through family support than single-parent families and families where both parents work outside of the home (Portes, 1998). This family support may be necessary because of a lack of community support, or lack of membership in outside networks. Coleman offers the following example that highlights the positive consequence of family support:

In one public school district where texts for school use were purchased by children's families, school authorities were puzzled to discover that a number of Asian immigrant families purchased two copies of each textbook needed by the child, rather than one. Investigation showed that the second copy was purchased for the mother to study in order to maximally help her child do well in school. (p. 233). The Asian immigrant mothers can be considered as being low in human capital due to low education attainment, but high in social capital that was distributed down to their children. Network mediated benefits is the most common positive consequence and more aligned with Bourdeiu's concept of social capital (Portes, 1998). Capital is gained from outside of the family, through membership in networks, and can help explain "access to employment, mobility through occupational ladders, and entrepreneurial success" (Portes, 1998, p. 12).

Although social capital is usually viewed positively, there are negative consequences for people that do possess social capital: a) restricted access to opportunities; b) restrictions on individual freedom; c) excessive claims on group members; and d) downward leveling norms. Group members pull together to share resources, but this solidarity can exclude outsiders to opportunities, for instance, individuals in parent groups may network to help themselves and locate resources for their children, but close-out others that do not meet the values and standards of individuals from other groups. Another negative consequence of social capital is conformity that some groups require that trample on individual freedoms. Portes (1998) reports that the literature has shown "that high levels of familistic solidarity among recent immigrant students are negatively related to four different educational outcomes, including grades and standardized test scores" (p. 17). The third negative effect can circumvent success in groups due to individuals in the social structure taking advantage of the resources of privileged members in the social network, basically getting a "free-ride" from access due to group membership. Downward leveling norms occur when oppressed group's solidarity are undermined by success stories of a few; therefore, the group pressures individuals to either stay in place (stop upward mobility) or force motivated individuals to leave the group (Portes, 1998). An example of this negative consequence is when African American students describe other members of their racial group as "acting White," if they are high academic achievers.

Previous Research on Social Capital

Coleman takes into account the positive consequences of social capital and does not explore the negative consequences in his research of families and schools (Coleman, 1987, 1988). Through Coleman's (1988) research on school outcomes of students in public and private schools, he found that while human capital in the parents were important, it was social capital in the family (and community) that significantly reduced dropout rates of students. Social capital worked positively for students because of "obligation and expectations, which depend on trustworthiness of the social environment, information-flow capability of the social structure, and norms accompanied by sanctions" (Coleman, 1988, p. S119). Hence, parents time and effort (social capital) spent with children can create human capital (better school outcomes) for their children.

A more recent article by Monkman, Ronald, and Theramene (2005) explored how cultural and social capital work together to reproduce inequality in an urban, low-income elementary school of Spanish-speaking families. They found that "cultural resources, activated and transformed into cultural capital, are transmitted via social networks when social capital is activated. Denying access to vertical ties, and the resources available through these ties, perpetuates the stratified nature of social relations and social benefits" (Monkman, et al., 2005, p. 26). In other words, the students' teacher was a resource for a social network, which opened varied and additional cultural resources that students were able to transform into cultural capital. If the students were denied access to this vertical tie, namely their teacher, or if they could not activate this vertical tie, then resources would not be available and they would remain in their differentiated social existence affecting their human capital. Monkman et al.

(2005) found that social reproduction of inequality can be disrupted for immigrant, low-income families if principals, teachers, and staff that come from more heterogeneous backgrounds include families in their social networks.

Background of Math and Science Development

A brief review of math and science development, as will be explained though discussion of developmental processes and models of development, is necessary to understand parameters of growth analysis, that is initial status, rate of growth, and slope of growth. Although learning is a continuous process over time, it can be linear or non-linear. Variation in math and science achievement may lead to different initial status, trajectory rates, and shapes of the growth trajectories for students' math and science growth.

Before reviewing a model of math development, math competence is reviewed because of the strong focus of growth in this domain. The way math competence is defined directs how math development is viewed and how math is taught in school and home. In the past, math was defined as quantitative knowledge manipulated by rules and algorithms, but currently math is defined as the "development of math competence rests, fundamentally, on the development of cognitive structures that permit a child to interpret the world of quantity and number in increasingly sophisticated ways, to acquire new knowledge in this domain…and to solve the range of problems that the domain presents" (Griffin, 2003, p. 10). The knowledge structures that Griffin references can be traced to brain structures that are attuned to quantitative thought that is supported by the evolution-based model of cognitive development. The evolution-based model states that cognitive development reflects biological, environmental, and cultural factors (Geary, 1995). While that statement seems obvious, Geary

(1995) uses the model to better separate biology from environment in terms of math development by concluding that there are biologically primary and secondary quantitative abilities. In short, they are abilities that develop in all children globally (biologically primary abilities) and other abilities that are specific to children in certain cultures or environments (biologically secondary abilities). Biologically primary quantitative abilities emerge during infancy and continue to develop without formal school well into preschool age (Geary, 2000). Biologically secondary quantitative abilities usually occur and develop during primary and secondary school, when children enter and regularly attend school (Geary, 2000).

Beginning in infancy, young children can accurately determine the number of a small set of items without counting the items (numerosity), understand more and less than (ordinality), count upwards of 3 to 4 items pre-verbally, and add and subtract items (Geary, 1995; Geary, 2000). These abilities are not taught but innate knowledge all infants and preschoolers possess that forms a structure on which more complex quantitative ability is built. Therefore, there is an expected universal developmental trajectory for all children leading up to formal schooling in quantitative abilities. These inherent abilities can be extended by the environment, but for the most part all children are on similar trajectories and approximate rates of math development from birth to preschool (Geary, 2000). The Early Childhood Longitudinal Study, Kindergarten Cohort's sample of students were assessed on math domains that covered a) number sense, properties, and operations, b) measurement, c) geometry and spatial sense, d) data analysis, statistics, and probability, e) and patterns, algebra, and functions. Consistent with the evolution-based model, the initial scores of the students' on the math assessment at the beginning of kindergarten will be similar and any variance could be accounted for by students that attended preschool, a form of formal schooling.

Once children enter school, “the normative development of secondary abilities can, and often does, vary from one culture or generation to the next” (Geary, 2000, p. 13) depending on the home and school environment. During this time-period, math strands in number and counting, computations, and word problems increases in complexity. Development occurs and builds upon previous abilities, but more variance is expected for school-aged children because their environment and cultural expectations differ. According to Geary (1995), “the development of biologically secondary abilities, in contrast (to biologically primary abilities), does not appear to have these biological advantages, and, as a result, their acquisition is generally slow, effortful, and occurs only with sustained formal or informal instruction” (p. 27). The advantages of biologically primary quantitative abilities include young children’s enjoyment of quantitative-type activities and the interaction between neurobiological and neurocognitive systems (Geary, 1995). Since continued acquisition of quantitative abilities can be a slower and more complex process, school-aged children may not have the same innate interest that they had when they were younger; thereby possibly affecting their math development. The other major difference is that children no longer receive instruction from the home, but school as well, which will influence the slope and rate of the growth trajectory in math development. While the science domain does not have an overarching developmental theory as does the mathematical domain, there are research perspectives concerning science learning that is explored. The perspectives allow for a “framework for identifying mechanisms governing how individuals change their knowledge and thinking processes” (Eylon & Linn, 1988, p. 251) in science education. The four research perspectives are concept-learning, developmental, differential, and problem solving.

The concept-learning perspective suggests that science students' initial understanding of scientific phenomena is incorrect and that the content and structure of knowledge needs to be altered by in-depth coverage of scientific concepts (Eylon & Linn, 1988). This perspective views scientific knowledge and growth as a very long list of scientific ideas that students learn through repeated comprehensive instruction. The initial status and rate of growth will vary for students depending on their assimilation of new correct scientific knowledge.

The developmental perspective takes a different view and posits that students make qualitative changes, which affects what and how they learn scientific phenomena (Eylon & Linn, 1988). Piaget's developmental theory (Selig & Rider, 2006) and Vygotsky's zone of proximal development (Selig & Rider, 2006) are the major features of this perspective. With the emergence of formal reasoning, students can think abstractly and reflect on scientific ideas, facilitating understanding of scientific phenomena that was not available during the concrete stage. Vygotsky believed that students are limited by their accumulation of new information by a "construction zone," but growth can and will occur in this zone with instruction by a person with more knowledge than the student. Therefore, the developmental perspective states that scientific growth occurs globally once there are qualitative structural changes within the students. This means that initial status and growth of scientific knowledge will not vary much among age-mates.

The differential perspective examines students that do well in science versus students that do not do well by studying scientific ability, aptitude, and psychosocial variables. Although researchers have attempted to explain scientific conceptual change by aptitude-treatment interactions, they have been stymied by disentangling science content knowledge, learning environment and cultural context (Eylon & Linn, 1988). Furthermore, a positive correlation between scientific proficiency and crystallized and fluid ability has been found (Eylon & Linn, 1988), but the variance explained is small, hampering further research in this vein. Initial status and growth in scientific knowledge will vary because students' have different abilities.

The last perspective, problem solving, attempts to use explicit strategies in problem solving to increase students' scientific knowledge, but is impeded by the general ability of the student and the limitation of focusing on topic-specific science content. According to this perspective, students will vary in initial status and growth in scientific knowledge.

All four perspectives attempt to explain how students learn new scientific information, but the picture of the science student shifts according to the perspective. The science student can be focused on learning specific science concepts (concept-learning perspective), limited by their intellectual capabilities at certain ages, while highlighting information-processing (developmental perspective), strictly bound by general and specific abilities (differential perspective), or a science student that uses "domain-specific and more general procedural skills and cognitive monitoring processes" (Eylon &Linn, 1988, p. 285) (problem-solving perspective). In summary, science development varies across the domain and depending on the perspective, learning can be linear (differential perspective) or non-linear (concept-learning, developmental, and problem-solving perspectives).

Parent Involvement and Achievement

The concept of family involvement in educational matters has shifted greatly from the beginning of formal schooling about 200 years ago to today. In the beginning, families controlled their children's schooling through hiring of teachers and influence over curriculum (Hiatt-Michael, 2006; Hill & Taylor, 2004); whereas, by the 1950s, there was more separation between family and school. Hill and Taylor describes that it became the family's responsibility to educate their child in early learning skills and the school to take over the child's academic needs once school began, while leaving the cultural, religious, and moral upbringing strictly to the family. In today's climate, there is the belief that parents and school should partner to direct the child's academic education (Hiatt-Michael, 2006; Hill & Taylor, 2004).

It is well-known that parents play an important role in the development of their children, but the positive impact of parents' involvement in their children's educational life as it pertains to student achievement has mixed results in the research literature. Some of the discrepancies are due to how parental involvement is operationally defined. In the past, parental involvement was measured as a uni-dimensional factor, but more recent studies have measured parental involvement as a multi-dimensional factor. Agreement upon what those dimensions are can be collapsed into three broad dimensions, home-based involvement, school-based involvement (Epstein, 1987) and parents' educational aspirations for child. Home-based involvement includes parent supervising child's time at home and parent communicating with child about academic issues (Fan & Chen, 2001; Hill & Tyson, 2009; Hong & Ho, 2005; Jeynes, 2005; Jeynes, 2007). School-based involvement includes parents attending events at school, parent contacting school, parent volunteering at school (Fan & Chen, 2001; Hill & Tyson, 2009; Hong & Ho, 2005; Jeynes, 2005; Jeynes, 2007). A third dimension, educational aspiration, includes parent educational expectations for child is measured in the literature (Fan & Chen, 2001; Hong & Ho, 2005; Jeynes, 2005; Jeynes, 2007). Hill and Tyson expands the educational aspiration dimension by also measuring "linking school-work to current events, fostering educational and occupational aspirations, discussing learning strategies with children, and making preparation and plans for the children" (p. 742) with middle school students and naming their dimension academic socialization.

Although parent involvement is no longer defined as a uni-dimensional factor, the different dimensions that form the parenting behaviors and practices are measured by different parental behaviors. Similar to previous research, it is expected that parent involvement will be multi-dimensional, specifically, home-based involvement, school-based involvement, and educational aspirations, which will be analyzed by confirmatory factor analysis.

Since parental involvement is a multi-dimensional factor, some dimensions have stronger relationships with academic achievement than other dimensions (e.g., Fan & Chen, 2001). In a meta-analysis of 25 studies, Fan and Chen found that parental home-based involvement, as measured by supervising time spent on activities at home, had the weakest relationship with academic achievement, and educational aspiration had the strongest relationship. Jeynes (2005) conducted a meta-analysis on urban elementary school families and his findings support Fan and Chen's; that parental expectations had a strong relationship with student academic outcomes, while parent behaviors, such as, attending school events and checking student homework, did not strongly impact student outcomes.

When considering middle school student academic achievement and parental involvement, education aspirations had greater impact than other parent behaviors with effect sizes over .80 (Jeynes, 2007). Hill and Tyson (2009) also found that parent education expectations, or academic socialization, was the strongest parental involvement strategy, as shown by the biggest positive relationship with middle school student academic achievement. While school-based parent involvement did have a positive relationship with academic achievement, home-based involvement had mixed results. Parents that were involved in their children's homework did not positively relate to students academic achievement, but other home-based involvement, such as visiting museums or libraries, which were positively associated with academic achievement.

Other factors, such as race/ethnicity and socioeconomic status, may affect the findings of parental involvement on student achievement. Domina (2005) found that after controlling for student variables (prior academic achievement, gender, race, grade, and public school vs. private school) and family background variables (socio-economic status and two-parent vs. single-parent family) parent involvement, including attending school events, volunteering at the school, and help with homework, is negatively related or not significantly related to child's academic achievement. This finding is not surprising considering those home-based and school-based activities have previously been found to not be as strongly related to achievement as parent's education aspirations for their children, which Domina did not test.

The multi-dimensionality of parent involvement was supported by Hong and Ho's (2005) study of the impact of parental involvement on the growth of students' eighth grade to twelfth grade academic achievement. They found that different dimensions of parental involvement had a differential influence on short- and long-term academic achievement across races. For all racial groups, parents communicating with their children about school and parents' educational aspiration significantly influenced students' scores in reading, mathematics, and science at the initial level and subsequent growth. Asian American parents that were involved in students' school events, communicating with school personnel, and visiting the classroom had a positive short- and long-term influence on their children's academic achievement. Whereas, African American parents' educational aspirations for their children only impacted the students' initial status and parental supervision influenced long-term growth. Hispanic families showed a short-term impact in parental communication, but not parental involvement dimensions influenced students' growth.

In regards to math achievement as a specific domain of academic achievement, Nokali, Bachman, and Votruba-Drzal (2010) did not find that parental involvement predicted math achievement in elementary school. Parent involvement was reported by the teacher and parent and operationally defined as volunteering at school, visiting school, importance of education in the family, and alignment of educational goals for the child between school and family. These parental involvement dimensions are slightly different from dimensions discussed above, which may reflect non-significant findings. As explained earlier in this section, definitions of parent involvement affect results. For example, home-based parental involvement, specifically help with homework is not found to have a strong relationship with academic achievement (Domina, 2005; Hill & Tyson, 2009; Jeynes, 2005), but Sheldon and Epstein (2005) reported that parents that are encouraged and taught how to effectively work on home learning activities with their children improved the students' growth and proficiency in mathematics. Sheldon and Epstein's home-based parental involvement variable was captured by specific activities from an intervention program: 1) parents or students were offered math game packets or lending-library activities to use at home; 2) students were assigned math homework that required them to show and discuss math skills with a family member; 3) families were offered videotapes on math skills to view at home or school; and 4) students and families were offered math activities on Saturdays.

McNeal (1999) used social and cultural capital as a framework to examine the differential effects of parental involvement domains on science achievement for eighth and tenth grade students from a nationally representative database. Parental involvement was operationally defined as a) parent-child discussion, b) parent-teacher organization involvement, c) parents monitor child's time at home, d) parents' involvement in the school, and e) educational support strategies. Increased parent-child discussion improved science achievement, but parent-teacher organization had a negative relationship with science achievement.

A study with a small sample (intervention sample = 40 and control sample = 40) of ethnic minority eighth grade students participating in a school science intervention program examined parental involvement and math and science achievement (Smith and Hausafus, 1998). Parental beliefs about the importance of math and science courses and parent educational aspirations, measured by supporting children's advanced and mathematics course enrollment, had more impact on achievement than attending parent/teacher conferences or having reading materials and science and math video games in the home. Smith and Hausafus found that it was not important that parents' had knowledge about mathematics or science at the middle school level or higher, but for parents to provide support in the home and in their positive beliefs about mathematics and science.

Race/Ethnicity and Socioeconomic Status and Achievement

There are factors other than parent involvement that can influence math and science achievement growth, such as race/ethnicity of student, family socioeconomic status (SES), and gender of student. A student's racial and cultural background matter as it relates to achievement, but it is rarely examined without socioeconomic status. Socioeconomic status can be measured in many different ways, as it conceptually "describes an individual's or family's ranking on a hierarchy according access or control over some contribution of values commodities such as wealth, power, and social status" (Sirin, 2005, p. 418). Traditionally, parents' income, education, an occupation were used as proxy for SES (Sirin, 2005).

There is an achievement gap between White and minority students and high SES and low SES families across different grades in kindergarten (Starkey & Klein, 2007) through 12th grade. Duncan and Magnuson (2005) describe the math achievement gap at kindergarten using the Early Childhood Longitudinal Study – Kindergarten (ECLS-K) cohort sample. When students entered school at kindergarten, African American and Hispanic students scored about two-thirds of a standard deviation below their White peers, 0.605 and 0.709, respectively on the math achievement test (Duncan & Magnuson, 2005). Family's SES explained approximately half a standard deviation of the kindergarten math achievement differences (Duncan & Magnuson, 2005). Not surprisingly, the SES of families in the sample was disparate; the average African American and Hispanic family SES was more than two-thirds of a standard deviation below the average White family (Duncan & Magnuson, 2005).

Minority students' math and science achievement scores on the National Assessment of Education Progress' (NAEP) Nation's Report Card show a significant gap between their White peers on the fourth grade and eighth grade assessment using a 0 – 300 scale (National Center for Education Statistics (NCES), 2009). According to the 2009 Nation's Report Card for mathematics, there were 26-and 21-point score gaps favoring White fourth graders over African American and Hispanic fourth graders, respectively. In the same year, there was a racial/ethnic score gap favoring White eighth graders over African American and Hispanic eighth graders; a 32- and 26-point score, respectively.

Family income, measured by eligibility for the National School Lunch Program, served as proxy for SES in the NAEP assessment. In fourth grade, students eligible for free lunch scored lower (nine points) than students eligible for reduced, who in turn scored lower (15 points) than students not eligible for free or reduced lunch. The SES results were similar for eighth graders, except the point spread was wider; 11 point difference between students eligible for free and reduced lunch and 19 point difference between reduced lunch and not eligible students.

The 2009 NAEP science test results are not yet available; therefore, the 2005 NAEP science achievement test is reported. The White –minority gap was present in fourth grade, African American students lagged by 33 points and Hispanic students lagged by 22 points and in eighth grade, African Americans scored 37 points lower and Hispanic students scored 32 points lower than White students (NCES, 2006). There was a 27 point gap between students eligible for the National School Lunch program (free or reduced lunch) and students not eligible in the fourth grade. The gap increased slightly to 28 points for eighth grades on the science NAEP between eligible and non-eligible students for the lunch program.

Recent meta-analysis of family SES and student achievement suggested strong correlation between the two because of parent's material resources and social capital (Sirin, 2005). Specifically, the average effect size of the correlation between SES and math achievement was 0.35 and between SES and science achievement was 0.27, which was higher than a general achievement variable. Race/ethnicity acted as a moderator in the meta-analysis because SES correlated strongly with academic achievement for White students than minority students. Samples that had a higher number of minority students had a weaker correlation between SES and achievement. Sirin noted that this may be due to more educational risk factors in the community where most minority families reside.

Few studies examine student race/ethnicity, family SES and achievement growth. Reardon and Galindo (2009) examined the White-minority math and reading achievement gap from kindergarten to fifth grade. Like Duncan and Magnuson (2005), they found a large math gap at kindergarten between the two groups of students, but saw that gap narrow by fifth grade for Hispanic students and widen for African American students. After six years of schooling, the Hispanic-White math achievement gap narrows by one-third of a standard deviation, leaving the average Hispanic student behind the average White student one-half a standard deviation. During the same time period, the White-African American math achievement gap widens by one-third of a standard deviation, meaning that the average African American fifth grade is slightly over one standard deviation behind the average White fifth grader. The authors believed that SES explains some of the score differences because of the large math achievement gaps at the beginning of school. In their ECLS-K sample, African

American and Hispanic students were more likely to belong to a low SES family than a high SES family.

When the results from the McNeal (1999) study discussed in the previous section are disaggregated by race/ethnicity, the parental involvement variable, school-related discussion was statistically significant for White and African American students, but not Hispanic and Asian students. Likewise, the negative PTO relationship with science achievement was statistically significant for White and African American students, not Hispanic and Asian students. Furthermore, family SES impacted the relationship between parental involvement and science achievement. McNeal found that if a student's SES was one standard deviation below the mean SES they no longer benefitted from the positive relationship between parental involvement and science achievement. Therefore, middle and upper SES families benefited the most from parental involvement.

Gender and Student Achievement

Since 1980, there has been growing evidence that while girls have as high or higher grades than boys in math (Duckworth & Seligman, 2006), girls are less likely to take math and science courses in school or enter science, technology, engineering, and mathematic (STEM) careers (Jacobs, 2005). The gender differences that are found in mathematics do not consistently favor boys until high school and are usually found on standardized achievement tests and among students in the higher levels of achievement (Muller, 1998). According to Jacobs, though much has been made of the gender gap in math abilities and standardized scores, the gap has steadily been narrowing. The 2009 NAEP math achievement test shows that in fourth grade and eighth grade boys outscored girls by only two points, the number decreasing by one point from 2007 for fourth graders and staying steady for eighth graders. In the science domain, there was a four point score gap in fourth grade and three points in eighth grade favoring boys over girls. For eighth graders the score gap decreased by one point from three points in the 2000 assessment and decreased by four points from seven points in 2000.

Leahey and Guo (2001) used two national datasets (National Longitudinal Survey of Youth and National Educational Longitudinal Study (NELS) 1988) to examine gender difference in math trajectories from students aged 4 to 18 years of age. Using curvilinear growth models they found that boys did have a slight math advantage over girls that emerged in high school in general math, reasoning, and geometry due to a greater acceleration rate. In contrast, LoGerfo, Nichols, and Chaplin (2006) found gender differences beginning in first grade (favoring boys) that widened over time using the ECLS-K and NELS 1988 datasets. The difference was statistically significant, but not practically significant because both genders average skills were on the same level in primary and secondary school. Like Leahey and Guo, boys' mathematical acceleration rate was higher than girls.

Lee and Burkam (1996) used the NELS data set to examine gender differences in eighth graders' achievement in life and physical sciences. Like previous research, eighth grade girls outscored boys on classroom grades, but scored lower on exam grades. They found that boys scored statistically significantly higher than girls in the physical science domain, while girls held a slight advantage over boys in life science. Also, Lee and Burkam examined the gender by ability interaction, which indicated that there was greater disparity in achievement scores in physical science among students with more ability.

In summary, math development will vary across elementary and secondary schooling. Although students' quantitative abilities are similar from birth to preschool, math achievement growth will vary because of the home and school environments of the students. Because of the lack of consensus of how science knowledge develops over time, the variation in growth depends on the perspective that is taken when studying scientific knowledge growth.

In regards to math and science achievement and parental involvement, there are different dimensions of parental involvement that is positively related to achievement. In general, home-based involvement, school-based involvement, and parent's educational aspirations for their child were related to increased math and science achievement.

Race/ethnicity, SES, and gender are usually included as covariates in previous research because of the influence on achievement outcomes. Specifically, White students from families with a middle- to high-SES level begin school better prepared for academic work and grow at a faster rate in math and science achievement. Gender and achievement is no longer as strongly correlated as it was in the past.

Overall, this present study will add to existing literature on mathematical and scientific achievement growth over time, clarify parental involvement domains that predict growth in achievement, and help determine which demographic variables influence growth in math and science achievement.

APPENDIX B

DETAILED METHODOLOGY

Factor Analysis of Parent Involvement Items

Factor analysis can be used to reduce a large set of related variables to a smaller set that is subsequently used in other analytical techniques, such as latent growth curve modeling. Factor analysis is divided into two main approaches: exploratory factor analysis (EFA) and confirmatory factor analysis (CFA). Tabachnick and Fidell (2001) explained that in EFA, usually the researcher "seeks to describe and summarize data by grouping together variables that are correlated" (p. 583), while CFA is usually reserved to 'confirm' or test a theory about variables underlying structure. Therefore, EFA is usually conducted early in the research process to generate hypotheses and CFA is used in the later stages of research to test those hypotheses. The present study used EFA on the nine common parent involvement items to determine the underlying factors of parent involvement and CFA to confirm those factors of parent involvement.

Study 1: Math Achievement

Exploratory Factor Analysis

Parents (*n* = 3,437) of children that participated in the Early Childhood Longitudinal Study – Kindergarten Cohort completed a parent involvement interview, which included nine items that were common to the fives waves of data collection being examined for math achievement. The responses of parents at each time point were used in exploratory factor analysis to determine the pattern structure of underlying factors in the data set. SPSS 16.0 Graduate Pack version was used to conduct a principal components analysis to reduce the nine items into a smaller set of latent factors that can reasonably explain a satisfactory percentage of variance in the original items. Seven of the nine items were dichotomously scored (yes/no) and one item was continuous. The last item asked parents about their expectations for their children's schooling and was scored on a six-point scale, ranging from "to receive less than a high school diploma" (1) to "to finish a PhD, M.D., or other advanced degree" (6). All of the items were normally distributed, except for item 9, the continuous variable, which asked parents about the number of parents in their child's classroom they spoke with regularly. Item 9 was slightly skewed (ranging from a low of 2.425 at kindergarten to a high of 3.259 at third grade) and leptokurtic (ranging from a low of 9.157 at fifth grade to a high of 19.191 at third grade); therefore, the item's responses were transformed by taking the square root of the item score (Tabachnick & Fidell, 2001). The square root transformed item was normally distributed, with skewness statistics of 0.559, 0.344, 0.407, 0.530, and 0.574 and kurtosis statistics of 0.241, -0.285, -0.082, 0.511, and 0.998 at kindergarten (Time 1) and first (Time 2), third (Time 3), fifth (Time 4), and eighth grades (Time 5), respectively.

At Times 1, 3, 4, and 5, two factors had eigenvalues greater than one (Kaiser, 1960) and inspection of the scree plot indicated two factors (Cattell, 1966). Although, the eiganvalues greater than one and scree plot tests were consistent concerning factor extraction, the minimum average partial (MAP) test was conducted because it tends to be more accurate than the aforementioned tests (Zwick & Velicer, 1986). MAP yielded one factor from the data and one factor was extracted, which explained 24.742 %, 25.479 %, 25.954 %, and 28.066 % of variance in the item correlation matrix at Times 1, 3, 4 and 5, respectively. At Time 2, three factors had eigenvalues greater than one and the scree plot indicated two factors, but MAP analysis yielded one factor, which explained 25.946 % of variance in the item correlation matrix.

Five items (3, 4, 6, 7, and 8) had moderate to high pattern/structure coefficients on the one factor, while the other four items did not, and were subsequently deleted. The one factor explained 36.895 %, 39.182 %, 37.469 %, 37.292 %, and 41.005 % of the variance in the five item correlation matrix. Table B.1 displays the descriptive statistics, factor pattern/structure coefficients, and communality scores.

The factor represents five items that reflect a parent's involvement in their child's school life through active participation and engagement with activities and events in the classroom and school and is named parent school involvement. Based on the descriptive statistics, approximately three-quarters or more of parents reported attending an open house or back-to-school event when their children were in kindergarten, first, third, and fifth grades. At the same time periods, about half of the parents volunteered at the school. From kindergarten to fifth grade, there was increased parent involvement in parent-teacher organizations and attendance in school events, while approximately two-thirds or more of the parents helped raise funds for their children's school. At Time 5, or eighth grade for most students, the parent involvement survey was administered in the fall instead of the spring, which artificially depressed parent involvement scores.

The initial coefficient alpha scores for all nine items were .038, .045, .018, .092, and .028 for Times 1, 2, 3, 4, and 5, respectively. The factor coefficient alpha estimates increased after the exploratory factor analyses to .569, .609, .571, .573, and .573 for Times 1 – 5. Although the factor coefficient alphas are much higher than the original coefficient alphas, they are still relatively low to moderate, possibly due to the small number of items.

Confirmatory Factor Analysis

CFA was conducted next to confirm the structure of parent school involvement factor using Lisrel 8.80. Tables B.2 and B.3 present fit indices and standardized path coefficients for the five item one-factor solution for time points 1 – 5. Absolute fit indices, such as chi-squared test and root mean square error of approximation (RMSEA) and incremental fit indices, such as normed-fit index (NFI) and comparative fit index (CFI) demonstrate how well the hypothetical model fits the data. The chi-squared test is a popular fit index that examines the magnitude of difference between the sample matrix and the fitted covariance matrix (Hooper, Coughlan, and Mullen, 2008). A good fit is determined by a p value greater than .05, but the chi-squared test is influenced by large sample sizes and the assumption of multivariate normality. RMSEA determines how well the model would fit the population covariance matrix and an RMSEA statistic of .06 or below is considered good fit (Hu and Bentler, 1999). The NFI and CFI indices assesses the model by comparing the chi-squared value to a null model and values of .95 or greater are indicative of good fit.

CFAs of the one factor structure of parent school involvement yielded good model fit across all five time points ($\chi 2$ = 16.54 to 78.49; RMSEA = .026 to .049; CFI and NFI = .97 to .99). Standardized path coefficients from the latent parent school involvement factor to the observed variables ranged from .34 to .62 across the five time points.

Study 2: Science Achievement

Exploratory Factor Analysis

The science achievement study examined three time points, Time 3, Time 4, and Time 5, at approximately third, fifth, and eighth grades. Parents (n = 3,964) of the students completed surveys at each time point and there were nine parent involvement items that were the same across the three waves of data collection. Exploratory factor analyses using SPSS 16.0 Graduate Pack version was conducted on the nine items at the three time points to generate the latent factor structure of parent involvement for the sample. One of the nine items, the number of parents in their child's classroom they spoke to regularly, was not normally distributed and was slightly to moderately positively skewed (Time 3 = 8.865; Time 4 = 2.474; Time 5 = 2.837) and leptokurtic (Time 3 = 121.782; 10.122; 12.539). The item was transformed by taking the square root of the values (Tabachnick & Fidell, 2001), resulting in normal skewness (Time 3 = .345; Time 4 = .298; Time 5 = .430) and kurtosis (Time 3 = .224; Time 4 = .100; Time 5 = .979) statistics for Times 3, 4, and 5. Another of the parent involvement items, parent's expectation for their child's school completion, had a six-point response scale, ranging from "to receive less than a high school diploma" (1) to "to finish a PhD, M.D., or other advanced degree" (6) and the remaining items were dichotomously scored (yes/no).

Principal components analyses resulted in two factors extracted at Times 3 and 4 by the eigenvalue greater than one test (Kaiser, 1960) and scree plot examination (Cattell, 1966), while at Time 5 three factors were extacted according to eigenvalue greater than one and two factors by inspecting the scree plot. Due to the inaccuracy of the eigenvalues and scree plot tests and their discrepancy at Time 5, MAP was conducted as well, resulting in one factor extracted at all time points (Zwick & Velicer, 1986). One factor explained 26.100 %, 27.426 %, and 27.408 % of the item correlation matrix at Times 3, 4, and 5, respectively.

Four items were deleted (1, 2, 5, and 9) at all time points because they had low pattern/structure coefficients for the one factor. The remaining five items explained more variance of the item correlation matrix than the original nine items, specifically 38.389 %, 38.558 %, and 39.730 % at Times 3 – 5. Table B.4 displays the descriptive statistics, factor pattern/structure coefficients, and communality scores for the science achievement parent involvement items.

The factor, named parent school involvement, captured parents' engagement and active involvement in their children's school life through attendance of events, volunteerism, and fundraising at the school. Almost half of the sample at Times 3 and 4 were involved in the parent-teacher organization and volunteered at the school, while more than three-quarters of the sample attended a school event at least once at Times 3 and 4. Over two-thirds of the sample helped their children fundraise at the school and over 80 % attended open house or a back-to-school event at Times 3 and 4. Parents were surveyed in the fall of Time 5, instead of the spring similar to other time points, which possibly depressed involvement participation rates. At Time 5, over half of the sample attended an open house or back-to-school night, and nearly half attended a school or class event, such as a science fair, and raised funds for the school. Approximately a quarter of the parents participated in the parent-teacher organization and volunteered at the school.

Internal consistencies for the original nine items were low at Times 3, 4, and 5, with Cronbach coefficient alphas of at .165, .182, and .151, respectively. The alphas improved to .587, .592, and .617 when the one-factor, five-item scale was assessed at time points 3 – 5.

Confirmatory Factor Analysis

Tables B.5 and B.6 present fit indices and standardized path coefficients for the parent school involvement factor at time points 3, 4, and 5. Confirmatory factor analyses of the one-factor parent school involvement construct yielded acceptable model fit (RMSEA = .036 to .056; CFI = .97 to .99; NFI = .97 to .98). Standardized path coefficients from the parent school involvement latent factor to the observed variables ranged from .35 to .65 at Times 3 and 4 and .44 to .60 at Time 5.

Table B.1

Study 1: Descriptive Statistics, Pattern/Structure and Communality Coefficients for 5 Items from the Parent Involvement Survey (n = 3,437)

		Time 1				Time 2				Time 3			
Item		Freq.	%	Factor 1	h^2	Freq.	%	Factor 1	h^2	Freq.	%	Factor 1	h^2
3. Attended an open house or back-to-school night?				.600	.360			.618	.381			.626	.392
	Yes	2,580	75.1			2,736	79.6			2,900	84.4		
	No	857	24.9			700	20.4			537	15.6		
4. Attended a meeting of a PTA, PTO, or Parent-Teacher Organization?				.524	.274			.591	.349			.495	.245
	Yes	1,288	37.5			1,499	43.6			1,555	45.2		
	No	2,149	62.5			1,938	56.4			1,882	54.8		
6. Attended a school or class event, such as a play, sports event or science fair?				.575	.330			.581	.337			.637	.405
	Yes	2,352	68.4			2,599	75.6			2,778	80.8		
	No	1,085	31.4			838	24.4			659	19.2		
7. Volunteered at the school or served on a committee?				.697	.486			.712	.506			.674	.455
	Yes	1,727	50.2			1,769	51.5			1,754	51.0		
	No	1,710	49.8			1,668	48.5			1,683	49.0		
8. Participated in fundraising for child's school?				.627	.394			.621	.385			.614	.377
	Yes	2,094	60.9			2,401	69.9			2,356	68.6		
	No	1,343	39.1			1,036	30.1			1,080	31.4		

(*table continues)*

Table B.1 *(continued).*

Item	Time 4				Time 5			
	Freq.	%	Factor 1	h^2	Freq.	%	Factor 1	h^2
3. Attended an open house or back-to-school night?			.394	.627			.628	.394
Yes	2,865	83.4			2,287	66.5		
No	571	16.6			1,150	33.5		
4. Attended a meeting of a PTA, PTO, or Parent-Teacher Organization?			.260	.510			.645	.415
Yes	1,506	43.8			801	23.3		
No	1,931	56.2			2,636	76.7		
6. Attended a school or class event, such as a play, sports event or science fair?			.372	.610			.580	.336
Yes	2,633	76.6			1,579	45.9		
No	804	23.4			1,858	54.1		
7. Volunteered at the school or served on a committee?			.496	.704			.702	.492
Yes	1,574	45.8			882	25.7		
No	1,863	54.2			2,555	74.3		
8. Participated in fundraising for child's school?			.348	.590			.642	.412
Yes	2,481	72.2			1,678	48.8		
No	956	27.8			1,759	51.2		

Table B.2

Study 1: Fit Indices for One Factor Model with Five Items

Fit Measure	Time 1	Time 2	Time 3	Time 4	Time 5
Chi Square	16.54	47.07	35.31	44.38	78.49
df	5	5	5	5	5
RMSEA	.026	.049	.042	.048	.065
90% CI of RMSEA	.013 - .040	.037 - .063	.029 - .055	.035 - .061	.053 - .078
CFI	.99	.97	.98	.97	.97
NFI	.99	.97	.98	.97	.97

Table B.3

Study 1: Path Coefficients for One Factor Model with Five Items

Item	Time 1	Time 2	Time 3	Time 4	Time 5
Item 3	.45	.43	.44	.43	.43
Item 4	.36	.34	.36	.37	.47
Item 6	.46	.46	.42	.45	.49
Item 7	.59	.58	.62	.59	.59
Item 8	.41	.44	.49	.44	.52

Table B.4

Study 2: Descriptive Statistics, Pattern/Structure and Communality Coefficients for 5 Items from the Parent Involvement Survey (n = 3,964)

Item		Time 3				Time 4				Time 5			
		Freq.	%	Factor 1	h^2	Freq.	%	Factor 1	h^2	Freq.	%	Factor 1	h^2
3. Attended an open house or back-to-school night?				.645	.416			.621	.386			.605	.366
	Yes	3,317	83.7			3,254	82.1			2,635	66.5		
	No	647	16.3			710	17.9			1,328	33.5		
4. Attended a meeting of a PTA, PTO, or Parent-Teacher Organization?				.512	.262			.502	.252			.635	.403
	Yes	1,826	46.1			1,675	42.3			920	23.2		
	No	2,138	53.9			2,289	57.7			3,044	76.8		
6. Attended a school or class event, such as a play, sports event or science fair?				.638	.407			.670	.449			.616	.379
	Yes	3,117	78.6			3,023	76.3			1,768	44.6		
	No	847	21.4			941	23.7			2,196	55.4		
7. Volunteered at the school or served on a committee?				.677	.458			.679	.461			.667	.445
	Yes	1,942	49.0			1,801	45.4			1,044	26.3		
	No	2,022	51.0			2,163	54.6			2,920	73.7		
8. Participated in fundraising for child's school?				.613	.376			.616	.379			.627	.394
	Yes	2,663	67.2			2,755	69.5			1,834	46.3		
	No	1,301	32.8			1,209	30.5			2,130	53.7		

Table B.5

Study 2: Fit Indices for One Factor Model with Five Items

Fit Measure	Time 3	Time 4	Time 5
Chi Square	31.29	58.48	69.14
df	5	5	5
RMSEA	.036	.051	.056
90% CI of RMSEA	.025 - .048	.040 - .063	.045 - .068
CFI	.99	.97	.98
NFI	.98	.97	.97

Table B.6

Study 2: Path Coefficients for One Factor Model with Five Items

Item	Time 3	Time 4	Time 5
Item 3	.46	.44	.44
Item 4	.35	.35	.50
Item 6	.43	.45	.47
Item 7	.61	.61	.60
Item 8	.48	.45	.51

APPENDIX C

MATH ACHIEVEMENT RESULTS

Descriptive statistics for the sample are presented in Table C.1. The sample consisted of 51.9 % female students and the majority of students attended public school (84.7 %) in kindergarten. Over half of the sample was White (57.4 %), 18.1 % Hispanic, 17.1 % African American, 4.4 % other ethnicities, and 3.0 % Asian American. Students in the “other” ethnicity category included students that identified as American Indian, Alaska Native, Native Hawaiian, other Pacific Islander, or multiracial. Kindergarten students’ schools were located in large to mid-size cities (36.8 %), suburbs and large towns (42.0 %), and in small towns or rural areas (21.2 %). The average kindergartner attended school where 33.05 % of the students were eligible for free lunch. Family socioeconomic status, based on parents’ education, income, and occupation, was slightly above the population mean of zero in spring of kindergarten and below the mean in springs of first, third, fifth, and eighth grades. At each time point, the average parent school involvement factor was below the theta estimate mean of zero. The math achievement outcome variable grew positively from fall kindergarten to spring eighth grade.

Unconditional Model

The unconditional latent growth curve model (LGM) was developed to demonstrate change in math achievement over time, kindergarten through eighth grade. A linear model was estimated, Model 1a, with loadings for the intercept fixed at 1 to signify the initial level of growth at fall kindergarten. The slope paths were fixed to 0, .5, 1.5, 3.5, 5.5, and 8.5 to reflect time between data collection. Fall kindergarten was the initial time point, thus the loading was set to 0. The next measurement occasion, spring kindergarten, was approximately six months later, first grade was a year and a half after the initial time point, third grade was three and a half years later after fall kindergarten, fifth grade was five and a half years later, and eighth grade was eight and a half years later.

As shown in Table C.2, the fit of Model 1a was unacceptable, evidenced by a high chi-square statistic (9549.305, p<0.001), a low CFI (.317) and TLI (.359), and a high RMSEA (.295, confidence interval [CI] 90 = .295, .300). A quadratic model was developed to allow for the decline in growth at latter time points. Model 1b fit better than the previous model, χ^2 (12) = 624.613, p<0.001; CFI = .956; TLI = .945; RMSEA = .086, (CI) 90 = .081, .092, but the chi-square was elevated and the RMSEA was above the usual cut-off of .06. To improve model fit, Model 1b was edited to allow errors to correlate for some time points. Specifically, there were correlated errors of the math achievement outcome variables at spring kindergarten and first grade, first grade and fifth grade, and first grade and eighth grade. Correlating error terms for repeated latent variables may improve fit because it can correctly model the error covariance structure (Chan, 1998). Model fit slightly improved, with a lower chi-square and higher CFI (see Table C.2).

A piecewise growth model, Model 1c, was specified to take into consideration the achievement changes that may occur during academic time periods, such as the transition from late elementary to middle school. The measurement occasions were subdivided into two pieces, fall kindergarten to third grade and third grade to eighth grade. The intercept coefficients were constrained to 1 and the two slope coefficients were fixed at 0, .5, 1.5, 3.5, 3.5, 3.5 and 0, 0, 0, 0, 5.5, 8.5, respectively. Model fit for Model 1c was slightly worse than the previous two models, resulting in χ^2 (10) = 701.450, p<0.001; CFI = .950; TLI = .926; RMSEA = .100, (CI) 90 = .094, .107.

Model 1b was the best fitting among the other models, thus retained and parameter estimates are reported in Table C.3. The mean initial level of math achievement was 26.275, mean slope of 25.728, and mean quadratic slope of -1.447. The positive linear slope means that students grew at an average rate of 25.73 points per year in math achievement, but there was a decline of the growth curve, signified by the negative quadratic term. The intercept, slope, and quadratic variances were statistically significant, indicating that there was interindividual difference among students' math achievement growth across time. Covariance between the intercept and slope suggested that students that initially had increased math achievement scores also had increased growth rates. Covariances between the quadratic term and intercept and the quadratic term and linear slope signified that higher initial math achievement and rapid linear growth was related to less quadratic curvature.

Conditional Models

Time Invariant Covariates

Table C.3 presents estimates of Model 2 predicting math achievement over time with school-level variables. Model 2's fit was tenable, as evidenced by the following chi square statistics and fit indices: χ^2 (21) 552.598, $p < .001$, CFI = .967, TLI = .939, and RMSEA = .061, (CI) 90 = .056, .065. Students schooled in suburban areas and private schools had higher initial levels of math achievement, while attending schools that had increased rates of free lunch eligible students was negatively related to initial math achievement and growth from kindergarten to eighth grade. Students that attended schools in rural areas or small towns had a decline in growth rate over time.

Time Varying Covariates

Table C.3 presents estimates of Model 3 predicting math achievement from kindergarten to eighth grade with the time varying predictor, SES. As shown in Table C.2, CFI (.944) and TLI (.915) fit indices decreased from Model 2, but the RMSEA index decreased to .054, (CI) 90 = .051, .057, which signified an acceptable fit to the sample data. The school-level variables' relationships with the intercept and slopes were the same in Model 3, as in Model 2. The time varying covariate represented the unique effects of SES directly upon the time-specific measures of math achievement above and beyond the effects of the underlying growth of math achievement. From first to eighth grade, SES was positively associated with math achievement growth, after controlling for school variables and the developmental math trajectory.

Model 4 is the final full theoretical model for the full math sample that includes the time varying predictor, parent school involvement (see Figure C.1). As shown in Table C.2, model fit was acceptable, χ^2 (71) = 996.976, $p < .001$; CFI = .944; TLI = .922; and RMSEA =.044, (CI) 90 = .041, .046. School-level variables and the SES variable that were statistically significant in Models 2 and 3 were significant in this model as well. Parents that reported increased parent school involvement at kindergarten, fifth grade, and eighth grade had children with higher math achievement at those same grades, above and beyond their general math growth trajectory.

Multiple-Group Growth Models

Gender

Multiple-group latent growth curve models were used to examine how growth trajectories differ by group (Duncan, Duncan, Strycker, 2006). Gender was used as the grouping variable to examine math achievement growth differences for girls compared to boys. Model 5a is a multiple-group growth model developed to test the non-linear growth fit for girls and boys without constraining any parameters. According to the CFI (.974), TLI (.950), and RMSEA (.038, [CI] 90 = .033, .042) indices, model fit was good. Male students' mean intercept (26.230) and mean linear slope (27.933) was higher than females students (25.769 and 27.293), and both quadratic terms were negative. Also, boys and girls had differences in variances of the intercept and slopes.

Model 5b constrained intercepts and slopes across gender to test parameter invariance. The model fit was acceptable (χ^2 (145) = 1139.204, $p < .001$; CFI = .942; TLI = .920; and RMSEA =.045, [CI] 90 = .042, .047), and the model was retained because the chi square difference test using the scaling correction factor was not statistically significant, $\Delta\chi^2(3) = 5.458$, $p = .141$. Since there were differences across gender of variances and covariances, Model 5c was constructed and those parameters wee constrained. Compared to Model 5b, Model 5c had comparable model fit, but the chi square difference test was statistically significant ($\Delta\chi^2(3) = 27.255$, $p < .001$); therefore, Model 5c was rejected and Model 5b was accepted. Model fit indices are in Table C.2 and parameter estimates are in Table C.4.

Boys' residual variance of intercept (82.356), linear slope (43.474), and quadratic slope (.367) was higher than girls (58.788, 37.348, .300), indicating that boys had more variance that was not explained by the model, especially at the intercept. Boys that attended suburban schools, private schools, and schools with low percentages of free lunch eligible students in kindergarten had higher math achievement at the intercept. The linear growth rate was slower over time for students that attended schools with high numbers of free lunch eligible students, and their quadratic curve indicated a downward trend. In first through eighth grade, SES was positively related to math achievement at those time points. The parent school involvement latent variable had a positive association with math achievement at fifth grade, accounting for individual differences and normal math achievement growth.

The same school-level variables that predicted boys' math achievement at the intercept did so for girls also, but their rate of growth differed. Girls that attended rural schools, public schools, and schools with high percentages of free lunch eligible students at kindergarten had slower math achievement across elementary and middle school. After controlling for other variables and the math achievement developmental trajectory, SES was positively related to math achievement at third, fifth, and eighth grades. Unlike boys, high parent school involvement at kindergarten, fifth, and eighth grades, was associated with high math achievement growth at those time points.

Ethnicity

Ethnicity was a grouping variable for the multiple-group LGM to examine parameter invariance across African American, Asian American, Hispanic, White and students categorized as other. As shown in Table C.2, Model 6a was the baseline model (no constraints) and model fit was acceptable. Mean intercepts differed by race/ethnicity, with "other" students having the highest initial math achievement (29.178) followed by White students (27.917), Asian American students (26.991), Hispanic students (21.443) and African American students (20.088). White students had the steepest math achievement growth rate (28.228), followed by Asian American students (28.219), "other" students (27.554), Hispanic students (27.11), and African American students (22.085). All races/ethnicities' covariance between intercept and slope was positive, and amongst the intercept and slope terms (linear and quadratic) the covariance was negative.

To test invariance of the intercept and slopes across ethnicity groups, Model 6b was developed and compared to the baseline model. The chi square difference test using the scaling correction factor was statistically significant, $\Delta\chi^2(12) = 35.508$, $p < .001$, consequently, the model was not retained. Model 6c constrained the variance and covariance estimates and was compared to Model 6a, but was rejected because of a statistically significant chi square difference test ($\Delta\chi^2(24) = 180.925$, $p < .001$. Model 6a was accepted and parameter estimates for this model are in Table C.5.

African American students that attended suburban schools or private schools at kindergarten had higher math achievement scores initially. However, students that attended rural schools at kindergarten had lower initial math achievement and a slower growth rate. SES in kindergarten and fifth grade was positively associated with math achievement at those time points, above and beyond the developmental trajectory. In eighth grade, parent school involvement was positively related to math achievement, after controlling for other variables and beyond the math growth rate.

Asian American students that attended schools with high percentages of free lunch eligible students in kindergarten had lower initial math achievement. Increased levels of SES were related to increased math achievement growth at first, third, and fifth grades. In contrast to African American students, Asian American students' parent school involvement variable was positively associated in early elementary, specifically kindergarten.

Hispanic students that attended private schools or schools with low percentages of free lunch eligible students had higher math achievement at kindergarten. Attending rural schools and schools with high percentages of free lunch eligible students had slower math achievement growth over time. Parent school involvement and SES at kindergarten and eighth grade was positively related to math achievement growth at those time points, after controlling for other variables and math developmental growth.

Rural schools, schools with high percentages of free lunch eligible students, and public schools were negatively related with initial math achievement for White students. There was a decline in math achievement growth for students enrolled in rural school and schools with high rates of free lunch eligible students at kindergarten. SES at all grades was positively related to math achievement growth, beyond math achievement developmental trajectory. At fifth grade, parent school involvement was positively related to growth at this time point.

Students categorized as other who attended rural schools and schools with high numbers of free lunch eligible students had decreased math achievement at kindergarten. Math achievement growth declined when students attended schools with high percentages of free lunch eligible students. Parent school involvement was only significant at fifth grade; high involvement was related to high math achievement growth.

Table C.1

Descriptive Statistics for Math Achievement, N = 6,861

	Fall kindergarten (K)			Spring K	1st Grade	3rd Grade	5th Grade	8th Grade
	Freq.	%	M (SD)	M (SD)	M (SD)	M (SD)	M (SD)	M (SD)
Gender								
Female	3,559	51.9						
Male	3,302	48.1						
Ethnicity								
African-American	1,171	17.1						
Asian-American	207	3.0						
Hispanic	1,242	18.1						
non-Hispanic White	3,939	57.4						
Other	303	4.4						
School Type								
Public	5,811	84.7						
Private	1,050	15.3						
School Location								
Large or Mid-size city	2,522	36.8						
Large and Mid-size Suburb and Large town	2,885	42.0						
Small town and Rural	1,454	21.2						
% Free Lunch at School			33.046 (27.567)					
Socioeconomic Status				.032 (.810)	-.002 (.801)	-.040 (.804)	-.016 (.800)	-.063 (.784)
Parent School Involvement				-.043 (.452)	-.041 (.438)	-.044 (.429)	-.044 (.435)	-.023 (.454)
Math Achievement			26.375 (9.174)	36.723 (11.999)	62.051 (17.940)	99.735 (25.02)	123.438 (25.386)	140.313 (23.038)

Table C.2

Math Achievement: Summary of Goodness of Fit for All Models

Model	χ^2	*df*	CFI	TLI	RMSEA	CI (90)	Description
Full Sample							
1a	9549.305	16	.317	.359	.295	.290 - .300	Unconditional Linear Model
1b	494.055	9	.965	.942	.089	.082 - .095	Unconditional Quadratic Model[a]
1c	701.450	10	.950	.926	.100	.094 - .107	Unconditional Piecewise Model
2	552.598	21	.967	.939	.061	.056 - .065	Conditional with School-level Variables
3	976.759	46	.944	.915	.054	.051 - .057	Conditional Model with School-level Variables and SES
4	996.976	71	.944	.922	.044	.041 - .046	Conditional Model with School-level Variables, SES, and Parent Involvement[a]
Multiple-group tests: Invariance across gender							
5a	1131.709	142	.942	.919	.045	.043 - .048	No constraints
5b	1139.204	145	.942	.920	.045	.042 - .047	Intercepts and Slopes constrained[a]
5c	1167.355	148	.940	.920	.045	.042 - .047	Variances and Covariances constrained
Multiple-group tests: Invariance across race/ethnicity							
6a	1585.832	365	.944	.924	.049	.047 - .052	No constraints[a]
6b	1622.430	377	.943	.925	.049	.047 - .052	Intercept and Slopes constrained
6c	1781.607	389	.936	.919	.051	.049 - .053	Variances and Covariances constrained

Note. CFI = comparative fit index; TLI = Tucker-Lewis index; RMSEA: root mean square error of approximation; CI (90) = 90% confidence interval of RMSEA.

[a] Model selected.

Table C.3

Unstandardized Estimates for Growth Curve Models of Math Achievement

	Unconditional Model	Conditional Models[a]		
	Model 1b	Model 2	Model 3	Model 4
Means				
Intercept	26.275***	26.009***	26.022***	26.016***
Linear Slope	25.728***	27.804***	27.748***	27.765***
Quadratic Slope	-1.447***	-1.637***	-1.632***	-1.632***
Variances				
Intercept	81.336***	71.013***	71.297***	71.211***
Linear Slope	46.506***	43.087***	41.115***	40.966***
Quadratic Slope	.381***	.355***	.348***	.345***
Covariances				
Intercept and Linear Slope	28.319***	22.652***	20.983***	20.948***
Intercept and Quadratic Slope	-2.779***	-2.307***	-2.212***	-2.209***
Linear and Quadratic Slopes	-4.103***	-3.809***	-3.676***	-3.656***
Predicting Intercept				
School Type		2.254***	2.256***	2.258***
Suburban School		1.635***	1.637***	1.637***
Rural School		-.019	-.112	-.110
% Free Lunch		-.092***	-.092***	-.092***
Predicting Linear Slope				
School Type		-.091	-.315	-.332
Suburban School		.521	.412	.403
Rural School		-1.262**	-1.213**	-1.219**
% Free Lunch		-.059***	-.048***	-.047***
Predicting Quadratic Slope				
School Type		.019	.032	.033
Suburban School		-.043	-.034	-.033
Rural School		.113**	.112**	.114**
% Free Lunch		.005***	.004***	.004***
Predicting Math Achievement				
SES at Kindergarten			.057	-.013
SES at 1st grade			.977**	.964**
SES at 3rd grade			2.971***	3.007***
SES at 5th grade			2.954***	2.789***
SES at 8th grade			3.842***	3.684***
Parent Involvement at Kindergarten				.671*
Parent Involvement at 1st grade				.493
Parent Involvement at 3rd grade				.473
Parent Involvement at 5th grade				2.054***
Parent Involvement at 8th grade				2.035***

Note. [a] In the conditional models, means are intercepts and variances are residual variances.
* p < .05; ** p < .01; *** p < .001

Table C.4

Gender Multiple-Group Analysis: Unstandardized Estimates for Growth Curve Models of Math Achievement

	Male	Female
n	3,482	3,379
χ^2	639.435	499.769
df	145	145
p-value	<.001	<.001
Means[a]		
Intercept	25.971***	25.971***
Linear Slope	27.601***	27.601***
Quadratic Slope	-1.611***	-1.611***
Variances		
Intercept	82.356***	58.788***
Linear Slope	43.474***	36.348***
Quadratic Slope	.367***	.300***
Covariances		
Intercept and Linear Slope	20.178***	20.938***
Intercept and Quadratic Slope	-2.222***	-2.157***
Linear and Quadratic Slopes	-3.873***	-3.217***
Predicting Intercept		
School Type	2.251***	2.307***
Suburban School	1.519*	1.811***
Rural School	.314	-.527
% Free Lunch	-.093***	-.090***
Predicting Linear Slope		
School Type	.445	-.911*
Suburban School	.500	.303
Rural School	-.0803	-1.661**
% Free Lunch	-.050***	-.042***
Predicting Quadratic Slope		
School Type	-.047	.087*
Suburban School	-.049	-.018
Rural School	.059	.169*
% Free Lunch	.004***	.004***
Predicting Math Achievement		
SES at Kindergarten	.144	-.154
SES at 1st grade	1.329**	.648
SES at 3rd grade	3.702***	2.322***
SES at 5th grade	2.705***	2.856***
SES at 8th grade	3.890***	3.292***

(table continues)

Table C.4 *(continued).*

	Males	Females
Parent Involvement at Kindergarten	.582	.779*
Parent Involvement at 1st grade	.745	.260
Parent Involvement at 3rd grade	-.390	1.450
Parent Involvement at 5th grade	2.041**	2.122*
Parent Involvement at 8th grade	1.042	2.888*

Note. [a] Means were constrained across groups. Means are intercepts and variances are residuals variances.

* $p \leq .05$; ** $p \leq .01$; *** $p \leq .001$

Table C.5

Race/Ethnicity Multiple-Group Analysis: Unstandardized Estimates for Growth Curve Models of Math Achievement

	African American	Asian American	Hispanic	White	Other
n	573	296	1,083	4,553	356
χ^2	161.146	189.448	203.352	895.619	136.267
df	365	365	365	365	365
p-value	<.001	<.001	<.001	<.001	<.001
Means					
Intercept	20.088***	26.991***	21.443***	27.971***	29.178***
Linear Slope	22.085***	28.219***	27.110***	28.228***	27.554***
Quadratic Slope	-1.213***	-1.576***	-1.520***	-1.672***	-1.634***
Variances					
Intercept	38.466***	107.830***	49.054***	84.582***	60.201***
Linear Slope	32.186***	33.080***	41.782***	40.763***	35.001***
Quadratic Slope	.221***	.267***	.352***	.389***	.279***
Covariances					
Intercept and Linear Slope	15.330***	21.277***	17.334***	19.112***	11.416***
Intercept and Quadratic Slope	-1.300***	-2.645***	-1.740***	-2.176***	-1.042***
Linear and Quadratic Slopes	-2.591***	-2.877***	-3.683***	-3.855***	-2.991***
Predicting Intercept					
School Type	3.090*	4.319	3.426***	1.844**	.111
Suburban School	1.807*	1.788	.151	.917	1.617
Rural School	-1.541*	.131	.172	-1.177*	-3.773*
% Free Lunch	-.019	-.105**	-.064***	-.073***	-.078**
Predicting Linear Slope					
School Type	-.075	-.965	-.459	-.275	.154
Suburban School	1.118	1.390	-.091	.025	-.272
Rural School	-2.219*	-.036	-3.036**	-1.102*	-4.092***
% Free Lunch	.001	-.014	-.026**	-.038***	-.023
Predicting Quadratic Slope					
School Type	.043	.080	.001	.026	-.002
Suburban School	-.063	-.145	.031	-.010	.044
Rural School	.186	-.071	.314**	.106*	.379**
% Free Lunch	.000	.001	.003**	.003**	.002
Predicting Math Achievement					
SES at Kindergarten	1.049**	.161	1.597***	-1.022***	-.272
SES at 1st grade	-.477	3.055**	.184	1.389**	.816
SES at 3rd grade	.880	8.70***	.850	4.223***	2.421
SES at 5th grade	3.385*	5.924**	.680	3.137***	1.389
SES at 8th grade	1.547	4.267*	2.443*	4.691***	.977

(table continues)

Table C.5 *(continued).*

	African American	Asian American	Hispanic	White	Other
Parent Involvement at Kindergarten	.937	2.220*	.949*	-.027	1.304
Parent Involvement at 1st grade	.804	1.704	.832	-.031	-.679
Parent Involvement at 3rd grade	2.624	1.054	.175	-.411	.414
Parent Involvement at 5th grade	2.950	1.525	1.393	1.507*	4.103*
Parent Involvement at 8th grade	4.838**	1.961	2.520*	.868	3.068

Note. Means are intercepts and variances are residual variances.

* $p \leq .05$; ** $p \leq .01$; *** $p \leq .001$

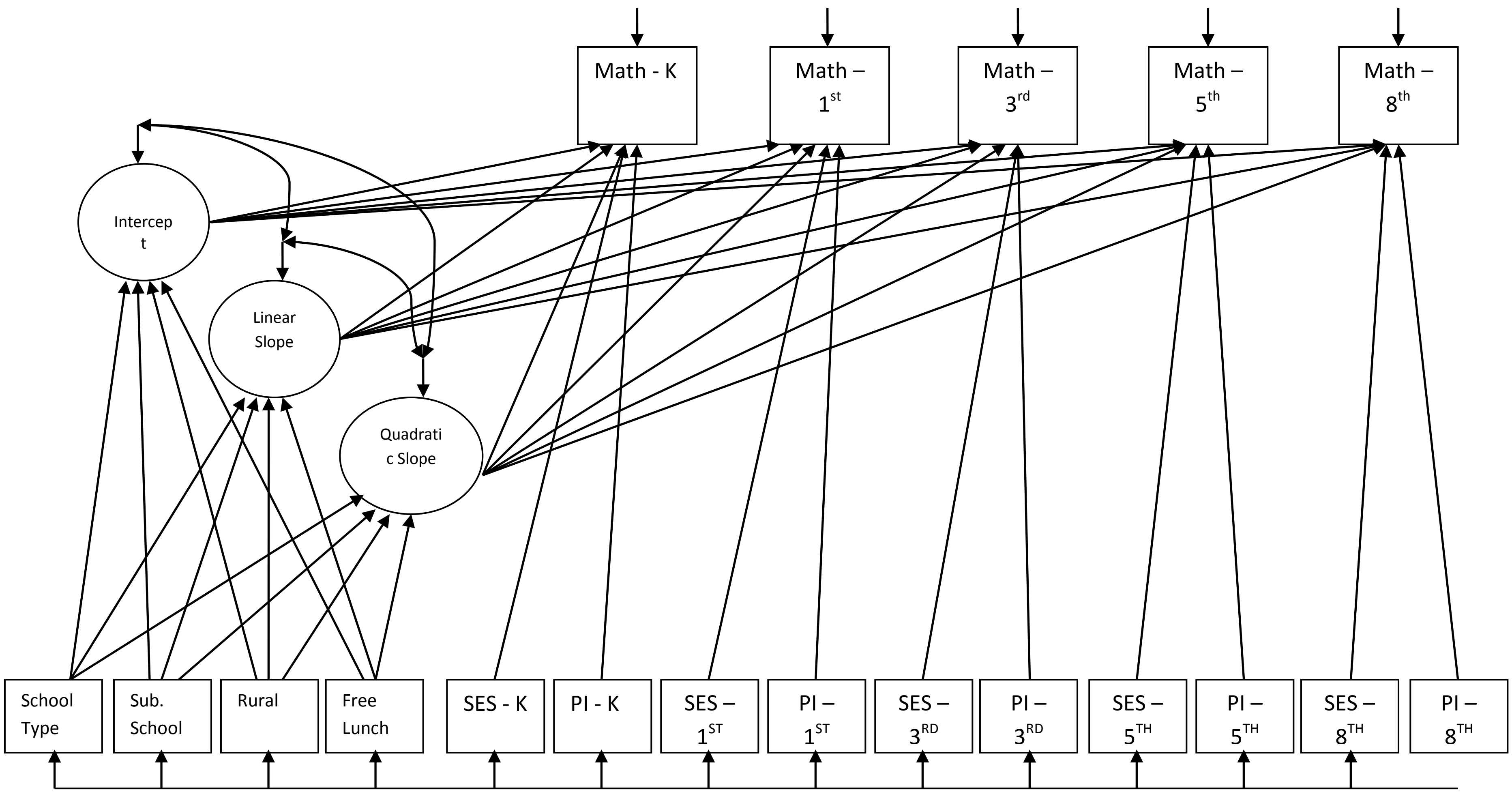

Figure C.1. Conditional latent growth curve model of math achievement with predictors. Math – K through 8th = math item response theory scores in springs of kindergarten (K), 1st grade, 3rd grade, 5th grade, and 8th grade, respectively; SES – K through 8th and PI – K through 8th = socioeconomic status and parent involvement at K, 1st grade, 3rd grade, 5th grade, and 8th grade; School type = public/private school at kindergarten; Sub. School = attendance in suburban school at K; Rural = attendance in rural school at kindergarten; Free Lunch = percentage free lunch eligible students at school.

COMPREHENSIVE REFERENCE LIST

American Association for the Advancement of Science. (1998). *Blueprints for reform: Science, mathematics, and technology education.* New York: Oxford University Press.

Baldi, S., Jin, Y., Skemer, M., Green, P. J., & Herget, D. (2007). *Highlights from programme for international student assessment (PISA) 2006: Performance of U.S. 15-year-old students in science and mathematics literacy in an international context*. Washington, DC: U.S. Department of Education.

Bourdieu, P. (1977). *Outline of a theory of practice*. New York: Cambridge University Press.

Bourdieu, P. (1986). The forms of capital. In J. Richardson (Ed.), *Handbook of theory and research for the sociology of education* (pp. 241 – 258). New York: Greenwood.

Browne, M. W., & Cudeck, R. (1993). Alternative ways of assessing model fit. In K. A. Bollen & J. S. Long (Eds.), *Testing structural equation models* (pp. 136–162). Beverly Hills, CA: Sage.

Carter, R. S., & Wojtkiewicz, R. A. (2000). Parental involvement with adolescents' education: Do daughters or sons get more help? *Adolescence*, *35*, 29-44. Retrieved from PubMed database (PMid: 10841295)

Chrispeels, J. H., & Rivero, E. (2001). Engaging Latino families for student success: How parent education can reshape parents' sense of place in the education of their children. *Peabody Journal of Education*, *76*, 119–169. doi:10.1207/S15327930pje7602_7

Catsambis, S. (1995). Gender, race, ethnicity, and science education in the middle grades. *Journal of Research in Science Teaching*, *32*, 243-57. doi:10.1002/tea.3660320305

Coleman, J. S. (1966). Equality of Educational Opportunity (COLEMAN) Study (EEOS), 1966 [Computer file]. ICPSR06389-v3. Ann Arbor, MI: Inter-university Consortium for Political and Social Research [distributor], 2007-04-27. doi:10.3886/ICPSR06389

Coleman, J. S. (1988). Social capital in the creation of human capital. *American Journal of Sociology*, *94*, S95-S120. doi:10.1086/228943

Coleman, J. S., & Hoffer, T. (1987). *Public and private high schools: The impact of communities*. New York: Basic Books.

Colwell, S. C. (n.d.). *Chi-square difference testing using the Satorra-Bentler scaled chi-square.* Retrieved from http://www.uoguelph.ca/~scolwell/qmlinks.html

DiMaggio, P. (1982). Cultural capital and school success: The impact of status culture participation on the grades of U.S. high school students. *American Sociological Review, 47*, 189-201. doi:10.2307/2094962

DiStefano, C., Zhu, M., & Mindrila, D. (2009). Understanding and using factor scores: Considerations for the applied researcher. *Practical Assessment, Research & Evaluation, 14*(20)*,* 1-11.

Domina, T. (2005). Leveling the home advantage: Assessing the effectiveness of parental involvement in elementary school. *Sociology of Education*, *78*, 233-249. doi:10.1177/003804070507800303

Duckworth, A. L., & Seligman, M. E. P. (2006). Self-discipline gives girls the edge: Gender in self-discipline, grades, and achievement test scores. *Journal of Educational Psychology*, *98*, 198-208. doi:10.1037/0022-0663.98.1.198

Dumais, S. A. (2002). Cultural capital, gender, and school success: the role of habitus. *Sociology of Education*, *75*, 44–68. doi:10.2307/3090253

Dumais, S. A. (2009). The academic attitudes of American teenagers, 1990-2002: Cohort and gender effects on math achievement. *Social Science Research*, *38*, 767-780. doi:10.1016/j.ssresearch.2009.05.010

Duncan, T. E., Duncan, S. C., & Stryker, L. A. (2006). An introduction to latent variable growth curve modeling: Concepts, issues, and applications (2nd ed.). Mahwah, NJ: Lawrence Erlbaum Associates.

Duncan, G. J., & Magnuson, K. A. (2005). Can family socioeconomic resources account for racial and ethnic test score gaps? *The Future of Children*, *15*, 35-54. doi:10.1353/foc.2005.0004

Epstein, J.L. (1987). Toward a theory of family-school connections: Teacher practices and parent involvement across the school years. In K. Hurrelmann, F. Kaufmann, and F. Losel (Eds.) *Social Intervention: Potential and constraint* (pp. 121-136). New York: de Gruyter.

Eylon, B. S., & Linn, M. C. (1988). Learning and instruction: An examination of four research perspectives in science education. *Review of Educational Research*, *58*, 251-301. doi: 10.3102/00346543058003251

Fan, X., & Chen, M. (2001). Parental involvement and students' academic achievement: A meta-analysis. *Educational Psychology Review*, *13*, 1-22. doi:10.1023/A:1009048817385

Feinstein, N. (2011). Diversity and equity in science education: Research, policy and practice. *Science Education, 95,* 571-573. doi: 10.1002/sce.20452

Geary, D. C. (1995). Reflections of evolution and culture in children's cognition: Implications for mathematical development and instruction. *The American Psychologist*, *50*, 24-37. doi:10.1037/0003-066X.50.1.24

Geary, D. C. (2000). From infancy to adulthood: The development of numerical abilities. *European Child & Adolescent Psychiatry*, *9*, 11-16. doi:10.1007/s007870070004

George, Y. S., Neale, D. S., Van Horne, V. V., & Malcolm, S. M. (2001). *In pursuit of a diverse science, technology, engineering and mathematics workforce*. Retrieved from American Association for the Advancement of Science website: http://ehrweb.aaas.org/mge/Reports/Report1/AGEP/AGEP_report.pdf

Gorad, S. & See, B. H. (2009). The impact of socio-economic status on participation and achievement in science. *Studies in Science Achievement, 45,* 93-129. doi: 10.1080/03057260802681821v

Greenfield, T. A. (1996). Gender, ethnicity, science achievement, and attitudes. *Journal of Research in Science Teaching*, *33*, 901-933.

Grenfell, M., & James, D. (1998). *Bourdieu and education: Acts of practical theory*. London: Falmer Press.

Griffin, S. (2003). The development of math competence in the preschool and early school years: Cognitive foundations and instructional strategies. In J.M. Roher (Ed.) *Mathematical cognition. In series: Current perspectives on cognition, learning, and instruction* (pp. 1-32). Greenwich, Ct.: Information Age Publishing, Inc.

Good, C., Aronson, J. & Harder, J. A. (2008). Problems in the pipeline: Stereotype threat and women's achievement in high-level math courses. *Journal of Applied Developmental Psychology*, *29*, 17–28. doi:10.1016/j.appdev.2007.10.004

Guiso, L., Monte, F., Sapienza, P., & Zingales, L. (2008). Diversity: Culture, gender, and math. *Science*, *320*, 1164. doi:10.1126/science.1154094

Hahs-Vaughn, D.L. (2005). A primer for using and understanding weights with national datasets. *The Journal of Experimental Education*, *73*, 221-248. doi:10.3200/JEXE.73.3.221-248

Hair, J. E., Anderson, R. E., Tatham, R. L., & Black W. C. (1998). *Multivariate data analysis*. (5th ed.). Upper Saddle River, NJ: Prentice-Hall.

Harris, A. & Goodall, J. (2008). Do parents know they matter? Engaging all parents in learning. *Educational Research, 50,* 277- 289. doi:10.1080/00131880802309424

Haworth, C. M., Dale, P. S., & Plomin, R. (2009). The etiology of science performance: Decreasing heritability and increasing importance of the shared environment from 9 to 12 years of age. *Child Development, 80,* 662-673. doi: 10.1111/i.1467-8624.2009.01289.x

Hiatt-Michael, D. B. (2006). Reflections and directions on research related to family-community involvement in schooling. *School Community Journal*, *16*, 7-30.

Hill, N. E., & Taylor, L. C. (2004). Parental school involvement and children's academic achievement. *Current Directions in Psychological Science*, *13*, 161. doi:10.1111/j.0963-7214.2004.00298.x

Hill, N. E., & Tyson, D. F. (2009). Parental involvement in middle school: A meta-analytic assessment of the strategies that promote achievement. *Developmental Psychology*, *45,* 740. doi:10.1037/a0015362

Honaker, J., King, G., & Blackwell, M. 2009. A*melia II: A program for missing data.* Retrieved from http://gking.harvard.edu/amelia/

Hong, S., & Ho, H. Z. (2005). Direct and indirect longitudinal effects of parental involvement on student achievement: Second-order latent growth modeling across ethnic groups. *Journal of Educational Psychology*, *97*, 32-42. doi:10.1037/0022-0663.97.1.32

Horn, L. & Kojaku, L. K. (2001). High school academic curriculum and the persistence path through college: Persistence and transfer behavior of undergraduates 3 years after entering 4-year institutions. *NCES Quarterly*, 3, retrieved from: http://nces.ed.gov/programs/quarterly/vol_3/3_3/q4-1.asp

Hu, L.T., & Bentler, P. (1995). Evaluating model fit. In R. H. Hoyle (Ed.), *Structural equation modeling: Concepts, issues, and applications* (pp.76-99). London: Sage.

Huss-Keeler, R. L., (1997). Teacher perception of ethnic and linguistic minority parental involvement and its relationships to children's language and literacy learning: A case study. *Teaching and Teacher Education*, *13*, 171-172. doi:10.1016/S0742-051X(96)00018-2

Jacobs, J. E. (2005). Twenty-five years of research on gender and ethnic differences in math and science career choices: What have we learned? *New Directions for Child and Adolescent Development*, *110*, 85-94. doi:10.1002/cd.151

Jeynes, W. H. (2005). A meta-analysis of the relation of parental involvement to urban elementary school student academic achievement. *Urban Education*, *40*, 237-269. doi:10.1177/0042085905274540

Jeynes, W. H. (2007). The relationship between parental involvement and urban secondary school student academic achievement. *Urban Education*, *42*, 82-110. doi:10.1177/0042085906293818

Joreskog, K., & Sorbom, D. (2009). *Lisrel 8.80 Student Edition*. Lincolnwood, IL: Scientific Software International, Inc.

Kalmijn, M., & Kraaykamp, G. (1996). Cultural capital, race and schooling: An analysis of trends in the United States. *Sociology of Education*, *69*, 22-34. doi:10.2307/2112721

Lareau, A. (1987). Social class differences in family-school relationships: The importance of cultural capital. *Sociology of Education*, *60*, 73-85. doi:10.2307/2112583

Lareau, A. (2001). Embedding capital in a broader context: The case of family-school relationships. In B. Biddle (Eds.), *Social class, poverty, and education* (pp. 77 – 100). London: Routledge Falmer.

Lareau, A., & Horvat, E. M. N. (1999). Moments of social inclusion and exclusion race, class, and cultural capital in family-school relationships. *Sociology of Education*, *72*, 37-53. doi:10.2307/2673185

Lareau, A., & Weininger, E. B. (2003). Cultural capital in educational research: A critical assessment. *Theory and Society*, *32*, 567-606. doi:10.1023/B:RYSO.0000004951.04408.b0

Leahy, E., & Guo, G. (2001). Gender differences in mathematical trajectories. *Social Forces, 80*, 713-732. doi:10.1353/sof.2001.0102

Lee, J., & Bowen, N. (2006). Parent involvement, cultural capital, and the achievement gap among elementary school children. *American Educational Research Journal*, *43*, 193-218. doi:10.3102/00028312043002193

Lee, V. E., & Burkam, D. T. (1996). Gender differences in middle grade science achievement: Subject domain, ability level, and course emphasis. *Science Education*, *80*, 613-650.

Levine, D. U., & Eubanks, E. E. (1990). Achievement disparities between minority and nonminority students in suburban schools. *The Journal of Negro Education*, *59*, 186-194. doi:10.2307/2295644

Levine, P. B., & Zimmerman, D. J. (1995). The benefit of additional high-school math and science classes for young men and women. *Journal of Business & Economic Statistics*, *13*, 137-49. doi:10.2307/1392368

LoGerfo, L., Nichols, A., & Chaplin, D. (2006). Gender gaps in math and reading gains during elementary and high school by race and ethnicity. Retrieved from Urban Institute website: http://www.urban.org/url.cfm?ID=411428

Ma, X. & Wilkins, J. L. (2002). The development of science achievement in middle and high school: Individual differences and school effects. *Evaluation Review, 26,* 395-417.

McNeal, R. B. (1999). Parental involvement as social capital: Differential effectiveness on science achievement, truancy, and dropping out. *Social Forces*, *78*, 117-144. doi:10.2307/3005792

Monkman, K., Ronald, M., & Theramene, F. D. (2005). Social and cultural capital in an urban Latino school community. *Urban Education*, *40*, 4-33. doi:10.1177/0042085904270416

Muller, C. (1998). Gender differences in parental involvement and adolescents' mathematics achievement. *Sociology of Education*, *71*, 336-356. doi:10.2307/2673174

Millar, R. (2008). Scientific literacy and its implications as a curriculum aim. In S. Mikelskis-Seifert, U. Ringelband & M. Bruckmann (Eds.), *Four decades of research in science* *education: From curriculum development to quality improvement* (pp. 43-56). Münster, Germany: Waxmann Verlag GmbH.Muthén, L. K., & Muthén, B. O. (2010). Mplus: Statistical analysis with latent variables - User's guide (6th ed.). Retrieved from http://www.statmodel.com

National Center for Education Statistics (2006). *The nation's report card: Science 2005* (NCES 2006466). National Center for Education Statistics, Institute of Education Sciences, U.S. Department of Education, Washington, D.C.

National Center for Education Statistics (2009). *The nation's report card: Mathematics 2009* (NCES 2010–451). National Center for Education Statistics, Institute of Education Sciences, U.S. Department of Education, Washington, D.C.

Newkirk, T. (2002). *Misreading masculinity: Boys, literacy, and popular culture.* Portsmouth, NH: Heinemann.

No Child Left Behind Act of 2001: Qualifications for Teachers and Professionals, 20 U.S.C. § 6319 (2008).

Nokali, N. E., Bachman, H. J., & Votruba-Drzal, E. (2010). Parent involvement and children's academic and social development in elementary school. *Child Development*, *81*, 988-1005. doi:10.1111/j.1467-8624.2010.01447.x

Nosek, B.A., Smyth, F.L., Sriram, N., Lindner, N.M., Devos, T., Ayala, A., Bar-Anan, Y., Bergh, R., Cai, H. & Gonsalkorale, K. (2009). National differences in gender–science stereotypes predict national sex differences in science and math achievement. *Proceedings from National Academy of Sciences, 106*, 10593-10597. doi: 10.1073/pnas.0809921106

Parsons, E. C. (2008). Learning context, black cultural ethos, and the science achievement of African American students in an urban middle school. *Journal of Research in Science Education, 45,* 665-683. doi: 10.1002/tea.20240

Portes, A. (2003). Social capital: Its origins and applications in modern sociology. *Annual Review of Sociology, 24*, 1-24. doi:10.1146/annurev.soc.24.1.1

Preacher,K. J., Wichman, A. L., MacCallum, R. C., & Briggs, N. E. (2008). *Latent growth curve modeling*. Los Angeles, CA: Sage.

Reardon, S. F., & Galindo, C. (2009). The hispanic-white achievement gap in math and reading in the elementary grades. *American Educational Research Journal*, 46, 853-891. doi:10.3102/0002831209333184

Rutherford, F. J. & Ahlgren, A. (1991). *Science for all Americans.* (2nd ed.). New York: Oxford University Press.

Satorra, A., & Bentler, P. (1999). *A Scaled Difference Chi-square Test Statistic for Moment Structure Analysis*. Retrieved from http://preprints.stat.ucla.edu/260/chisquare.pdf

Selig, C. K. & Rider, E. A. (2006). *Life-span: Human development* (5th ed.). Belmont, CA: Thomas Higher Education.

Schofer, E., Ramirez, F. O., & Meyer, J. W. (2000). The effects of science on national economic development, 1970 to 1990. *American Sociological Review, 65*, 866-887. doi:10.2307/2657517

Sirin, S. R. (2005). Socioeconomic status and academic achievement: A meta-analytic review of research. *Review of Educational Research*, 75, 417-453. doi:10.3102/00346543075003417

Smith, F. M., & Hausafus, C. O. (1998). Relationship of family support and ethnic minority students' achievement in science and mathematics. *Science Education*, *82*, 111-125. doi:10.1002/(SICI)1098-237X(199801)

Starkey, P., & Klein, A. (2008). Sociocultural influences on young children's mathematical knowledge. In O. N. Saracho & B. Spodek (Series Eds.), *Contemporary perspectives in early childhood education: Mathematics in early childhood education* (pp. 253-276). Greenwich, CT: Information Age Publishing.

Tabachnick, B. G., & Fidell, L. S. (2001). *Using multivariate statistics* (4th ed.). Needham Heights, MA: Allyn & Bacon.

Tourangeau, K., Lê, T., Nord, C., & Sorongon, A. G. (2009). *Early Childhood Longitudinal Study, Kindergarten Class of 1998–99 (ECLS-K), eighth-grade methodology report* (NCES 2009–003). Washington, DC: National Center for Education Statistics, Institute of Education Sciences, U.S. Department of Education. Retrieved from http://nces.ed.gov/pubsearch/pubsinfo.asp?pubid=2009003

Trueba, H. T. (1988). Peer Socialization among Minority Students: A High School Dropout Prevention Program. In H. T. Trueba & C. Delgado-Gaitan (Eds.) *School and society: Learning content through culture* (pp. 201-217). New York: Praeger.

Zimosky, M.F., Muraki, E., Mislevy, R.J., & Bock, R.D. (2007). *BILOG-MG-3*. Chicago: Scientific Software, Inc.