EFFECTS OF PARENTAL INVOLVEMENT ON MATHEMATICS ACHIEVEMENT AT EIGHTH, TENTH, AND TWELFTH GRADES

by

Duard G. Addington

Dissertation submitted to the faculty of the Virginia Polytechnic Institute and State University in partial fulfillment of the requirements for the degree of

Doctor of Philosophy

in

Educational Research and Evaluation

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July 1996
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(ABSTRACT)

Researchers, policy makers, and educators have recently drawn attention to parental involvement as an important predictor of mathematics achievement among U.S. students. Despite evidence proclaiming parental involvement's positive effect on younger students' academic achievement, inconsistencies in sparse research on older students seem the norm. The purpose of this research is to examine the effects of parental involvement on older children as they progress from eighth to twelfth grade in a specific area of achievement, mathematics achievement. Data from a large nationally representative sample of students and their parents who participated in the National Educational Longitudinal Study of 1988 base-year, first follow-up, and second follow-up were analyzed using latent structural equations analyses. The results suggest that
parental involvement in students' academic lives is indeed a powerful influence on student mathematics achievement at eighth, tenth, and twelfth grade. Findings also suggest that conscious efforts to improve parent/child communication concerning school related matters and increased efforts to communicate parental aspirations for their child's future educational attainment can act as a useful tool to help increase mathematics achievement at the secondary school level.
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Chapter 1

Effects of Eighth Grade Parental Involvement on Mathematics Achievement At Eighth, Tenth, and Twelfth Grades

Knowledge of mathematics is crucial in today’s highly specialized technological society. Mathematics learning is viewed by the public as vital to many areas of education, citizenship, and careers. Many colleges and universities spend considerable time and money for mathematics remediation; commerce and industry spend billions of dollars to supplement mathematics learning (National Alliance of Business, 1990). Mathematics everyday demands of today’s society, such as understanding the graphs that permeate the media and the regulations and procedures that underlie credit, discounts, taxation, and insurance further emphasize the importance of mathematics learning.

Given the significance of mathematics knowledge, recent national assessments of students’ mathematical competencies appear discouraging. "The mathematical skills of our nation’s children are generally insufficient to cope with either on-the-job demands for problem solving or college expectations for mathematical literacy." (National Research Council, 1989).

The presumed need to improve mathematical competencies in our students has gained national
attention. Such attention is evidenced by the ambitious Goals 2000 which proclaims that; "U.S. students will be first in the world in science and mathematics achievement by the year 2000". Although improvement of curriculum and instruction are core factors in efforts to improve mathematics competencies in our students, another less obvious factor is the potential for parents to influence their children's mathematics achievement.

Logic alone suggests that parents can have a positive influence on the academic achievement of their children. These suppositions find support and attention in a 1991 U.S. Department of Education study, The State of Mathematics Achievement. This study conducted on a nationally representative sample of 26,000 fourth, eighth, and twelfth grade students favors positive parent influence on mathematics proficiency (National Research Council, 1991).

Since actions indicative of parental involvement were not directly investigated in this study, it seems appropriate also to view parental involvement studied here as parental expectations for their children's success. By whatever rubric one labels this type of parental involvement, review of parental involvement research offers mixed conclusions.
Review of Selected Literature

Definitions of parental involvement vary greatly. The literature includes such varied operational interpretations as expectations of school performance, verbal encouragement or interactions regarding school work, direct reinforcement of improved academic performance, general academic guidance and support, parental monitoring of daily activities and school progress, and even student perceptions of parental influence on students' post high school plans (Keith, 1991; Seginer, 1983; Bronfenbrenner, 1974; Christenson, 1990).

Throughout the parental involvement literature, the general theme appears to be that parents can influence the academic achievement of their children. However, the nature and potency of the influence appears different between younger than older children. Parental involvement seems more influential for younger children with positive and consistent effects observed for preschool and elementary school age children. Parental involvement literature at the secondary school level, however, is more equivocal and much less consistent. Perhaps differing parental involvement
definitions associated with different data collection procedures may help explain many inconsistencies in parental involvement research findings across grade and/or age levels of student. Parental involvement is also usually measured differently for younger and older students. Two common methods for measuring the effects of parental involvement on academic learning in nonexperimental research use questions asked exclusively to parents or students. Keith's (1991) review of parental involvement literature suggests that research has been more likely to use students' perceptions of parents' involvement with older students whereas direct measures of parental involvement are typically used with younger pupils.

Pre-School Level Research

In a review of twelve studies on preschool level early intervention programs, Bronfenbrenner (1974) concludes that active involvement of the family is critical to early intervention program success. He maintains that parental involvement not only reinforces but helps sustain the effects of school programs.

Research Across Elementary and Secondary Levels
In a study of family-school relations and child school performance at both elementary and secondary school levels, Stevenson and Baker (1987) report that the younger the child the greater the degree of parental involvement with more involvement associated with better student performance. They also report that children of parents who are more involved in school activities do better in school than children with parents who are less involved. They suggest that early involvement is greater among parents who recognize the importance of early schooling and have confidence in their ability to assist their young children in school work. Stevenson and Baker studied a nationally representative sample of students ranging in age from five to seventeen years. The data set used was a subset of the Time Use Longitudinal Panel Study, an omnibus data set addressing questions on how families use their time and how their schedules affect their lives. The subsample studied consisted of 179 children and their teachers drawn from the original 620 households randomly selected for the Time Use Longitudinal Panel Study. The subset of data studied contained key variables with overall distributions not significantly different from those in the original larger
sample. Multiple regression techniques were used to analyze data collected from students, parents, and teachers. Parental involvement in children's school activities was defined by responses to the question, "To what extent did his/her parents get involved in the activities of the school such as PTO and parent-teacher conferences?" Parental involvement in schooling and the child's school performance were defined using teacher responses on two items: 1) Rate how the child performs in school, 2) Rate whether the child is performing to the child's ability. Although positive results were found, they are reported as "tempered", however, by the authors' acknowledgment of limitations to the study due to the use of cross-sectional data. The authors' apparent reliance on teachers' perceptions of parental involvement may also hamper clear-cut interpretations of findings.

Elementary School Level Studies

Henderson's (1981) review of related elementary school studies concludes that all research points in the same direction; the form of parent involvement is not critical if it is reasonably well-planned, thorough, and long-lasting. Keith's 1991 review of parental involvement and student academic performance shared many of Henderson's conclusions. Keith found that elementary
school level studies were abundant, consistent, and focused on the importance of parental involvement of almost any positive nature for elementary and younger students. Even students' perceptions of parental involvement appear highly related to academic learning for younger children (Seginer, 1983).

Secondary School Level Research

In contrast, secondary school level studies on parental involvement are fewer in number and offer much less consensus. The apparent inconsistencies may be due in part, to differences in definitions of parental involvement, differences in performance criteria, differences in data collection methods, and a possible reciprocal relationship between parental involvement definitions and measured performance criteria (Keith, 1991).

Fehrmann, Keith, and Reimers (1987) found significant positive effects for parental involvement on student achievement. Employing path analytic techniques, their results reveal significant total and direct effects of parental involvement on student achievement of (.157) and (.129) respectively. They studied 28,051 seniors included in the 1980 base year data of the nationally representative longitudinal study, High School and Beyond
(HSB). Parental involvement was defined as a weighted composite of five questions designed to measure students' perceptions of their parents' involvement in their daily lives. Questions included "My parents (or guardians) almost always know where I am and what I am doing", "My mother (stepmother or female guardian) keeps close track of how well I am doing in school", "How closely their fathers (stepfather or male guardian) monitor their school work, and "How much have your mother (stepmother or female guardian) and father (stepfather or male guardian) influenced your plans for after high school?" The achievement criterion was derived from students' self report of grades received so far in high school.

Background variables were also included in the study. This study's authors also note, however, that although High School and Beyond data is longitudinal in design with follow-up data available on these same students for 1982, 1984, and 1986, their research used only data collected in 1980 and, therefore, could not rule out reverse causation between parental involvement and achievement (Seginer, 1983; Stevenson & Baker, 1986). Also, they relied exclusively on pupil reports of parental involvement.
Although parental involvement has been found to be a valuable part of students' home life and a contributing factor to younger students' achievement (Christenson, 1990; Fehrmann, et al., 1987), some research defining parental involvement as parental structuring of the home environment for older students has not produced encouraging results.

A study which compared four definitions of parental involvement including parental academic aspirations and expectations for children, participation in school activities or programs, communication with children about achievement or school, and parental structuring of students' home environment found small but significant negative effects of parental involvement as defined by parental structuring of students' home environment on eighth grade student learning (Keith, T. Z., Keith, P., Troutman, G., Bickley, P., Trivette, P., & Singh, K., 1993). A nationally representative sample of 21,835 eighth graders from the National Educational Longitudinal Study of 1988 (NELS:88) was studied in a causal model using structural equations modeling techniques. Parental involvement was considered a latent construct measured by four variables designed to assess family rules concerning students' TV viewing, homework, and grades. Six items
were selected as indicators of parental involvement, four from parent data and two from student data. Parent data items included: 1) How many hours may your child watch TV on school days?, 2) Are there family rules about maintaining grade average? 3) How many hours may your child watch TV?, 4) Are there family rules about doing homework? Student data items included: 1) How often do parents check on homework? and 2) How often do parents limit time watching television? Achievement was a latent variable measured by standardized tests scores provided in NELS:88 on reading, mathematics, science, and social studies. Results uncover a modest but significant negative effect of parental involvement on achievement (-.097). Keith and colleagues (1993) contend that the negative effects resulted from parents who may have imposed rules in response to low academic achievement by their children and that imposition of rules is not always effective in improving achievement of eighth graders. The results suggest that the increased structure imposed on eighth graders by parents through rules concerning homework and television viewing can have detrimental effects on student achievement.

Another recent descriptive study conducted by the National Center for Education Statistics (1992) using the
same data set (NELS:88) reports that parental involvement and academic performance might be negatively associated among eighth grade students. The report suggests that students whose parents reported helping their child "almost daily" with homework were more likely to score below the basic level in mathematics or reading than students whose parents seldom or never helped. It was reasoned that an eighth grader who needs daily help with homework is one who is probably struggling in school. This relationship was found at all levels of socioeconomic status (NCES, 1992).

Another study using only student perceptions of their parents' involvement found no effect on student achievement test scores. Keith, Reimers, Fehrmann, Pottebaum, and Aubey, (1986) studied 28,051 high school senior included in the base-year data from the nationally representative longitudinal study, High School and Beyond (HSB) using path analytic techniques. Parental involvement was a weighted composite of five questions designed to measure students perceptions of their parents' involvement in their daily lives. The HSB reading, mathematics I, and mathematics II standardized tests were averaged to form the criterion achievement with scores weighted as half reading and half
mathematics.

There is still another source of inconsistency in the parental involvement literature at the secondary school level, dissimilar findings related to performance criteria studied. Two common criteria of academic performance studied in parental involvement research at all levels are students' grades and achievement test scores. Although both criteria appear positively effected at the elementary school level, some secondary school level research suggests little or no effects for parental involvement on achievement as measured by achievement test scores but positive effects on grades. Two studies using identical methodology, data, definition of parental involvement, but different criterion of performance revealed contrasting results. Keith et al. (1986) found no effects on high school seniors' achievement as measured by standardized achievement test scores. Fehrmann et al. (1987), on the other hand, found significant parental involvement effects on achievement as measured by students' grades. Both studies used the senior sample from the first wave (1980) of the High School and Beyond longitudinal study (HSB) and identical path analytic techniques. These conflicting results have been attributed to stronger parental involvement effects
on effort, thought to play a more important role in determining grades than achievement test scores (Keith & Page, 1985).

Keith et al. (1993) also investigated parental involvement effects on the general achievement of eighth grade students as measured by standardized test scores. Two basic questions guided the study: 1) Does parental involvement affect eighth grade students' academic achievement? and, if so, 2) How does parental involvement affect achievement through time spent on homework and time spent watching weekday television? To answer these questions, the National Educational Longitudinal Study of 1988 (NELS:88), a nationally representative sample of 21,814 eighth grade students and their parents, was studied using causal analyses and latent structural modeling techniques.

The model studied was designed to test the influence of general parental involvement on eighth grade student academic achievement, after controlling for relevant background variables, ethnicity, family background, and previous achievement. Model development was based on previous parental involvement research (e.g., Keith et al., 1986; Seginer, 1986), and theories of parental involvement (e.g., Epstein, 1987b; Marjoribanks, 1983;
Seginer, 1983). Results of the analysis indicated that parental involvement in students' academic lives can be a powerful influence on eighth grade students' general academic achievement as measured by standardized test scores. Separate achievement areas were also studied. Results suggest that all subject areas were strongly affected by parental involvement, with the strongest effect on mathematics. They also studied how parental involvement affects achievement. Two variables under partial parental control--time spent on homework and time spent in weekday television viewing--were added to the model. Support for these mediating variables was evidenced in school learning theory (Carroll, 1989) and previous parental involvement research (Keith et al., 1986). Findings indicate that homework displaces TV viewing; students who spend more time on homework watch less weekday TV. No meaningful effect of TV viewing on general achievement was found. The total effects of parental involvement on achievement, however, suggest that homework does not fully explain the effects of parental involvement on achievement. The authors reasoned that other mechanisms, possibly other time related variables, may explain much of the remaining effect.
In summary, research suggestion that parental involvement positively affects learning is strongly supported by research at pre-school and elementary school levels. Clear-cut conclusions from parental involvement research at the secondary level, however, are more equivocal. Sparse research at the secondary school level has yielded conflicting evidence across grade and/or age levels of subjects, varied operational definitions of parental involvement, and performance criteria. Many questions remain unanswered. Are there parental involvement effects at all secondary school grade levels? Do parental involvement effects differ for different subject areas? Do parental involvement effects depend on the performance criteria? At pre-school and elementary school levels parental involvement defined by either actual or perceived expectations for school success seem to affect achievement (Seginer, 1983). Do the effects differ when parental involvement is measured at the secondary school level by asking students rather than parents directly? Does the possibility of reciprocal causation between parental involvement and performance further cloud the interpretation of existing results? Can longitudinal data incorporating additional explanatory variables lead to more clear-cut conclusions?
Statement of the Problem

Given inconsistencies in secondary level parental involvement research results, and the importance of mathematics to our modern society, it seems appropriate to ask whether parents' involvement at the eighth grade exerts influences on their children's mathematics achievement not only at the eighth grade level, but later as these same students progress through high school. Parental involvement research is neither conclusive nor substantial. Research suggests that parental involvement investigations should consider specific grade levels, definition of parental involvement, performance criteria, and subject matter. National mathematics-based scientific interests and desire for better academic performance appear sufficient to support the need to investigate the potentially promising effects of parental involvement on secondary school level mathematics achievement.

The purpose of this research was to further investigate and shed additional light on parental involvement effects on secondary school level student achievement by extending previous research (e.g., Keith et al. 1993; Keith et al. 1986; Seginer, 1986) and theories of parental involvement (e.g., Epstein, 1987b;
Marjoribanks, 1983; Seginer, 1983). The extension of this previous research and theory was accomplished by:

1) Measuring academic achievement for the same cohort across four years, 1988, 1990, and 1992 as students were in the eighth, tenth, and twelfth grades, and 2) Defining parental involvement using indicators from both parents and their children from the NELS:88 base year data collected in 1988. Parental involvement effects on mathematics achievement were assessed at three different times on the same cohort of students at eighth grade, tenth grade, and twelfth grade. While it was expected that parental involvement would have a direct positive effect on mathematics achievement at all three grade levels, how this operates was explored by incorporating all three measures of mathematics achievement into a single longitudinal type causal model. It is reasoned that eighth grade parental involvement may operate indirectly on future mathematics achievement through prior mathematics achievement and that a cumulative effect of mathematics achievement may help to reveal the effects of eighth grade parental involvement on subsequent assessment of mathematics achievement. Though much theory and research on which this study was patterned investigated the effects of parental
involvement on general achievement across four academic subject areas, by contrast this study focuses on mathematics achievement exclusively.

A major limitation of survey data collected at one point in time is that one cannot rule out reciprocal causation (Loehlin, 1992; Pedhazur, 1982). By using data collected at a single point in time, it can be argued that parental involvement affects student achievement and student achievement, in turn, affects parental involvement (Stevenson & Baker, 1987; Seginer, 1983).

Although it may be argued that the assessment of parental involvement effects in 1988 may involve reciprocal causation with 1988 mathematics achievement, using parental involvement data from 1988 and mathematics achievement data from 1990 and again in 1992 makes it untenable to assert that mathematics achievement measures taken in 1990 and again in 1992 could affect parental involvement measured in 1988. This study assessed the effects of eighth grade parental involvement on mathematics achievement not only cross-sectionally in 1988 but also two and four years later, thus allowing unambiguous conclusions concerning direction of causal relationship between parental involvement and students' mathematics achievement in 1990 and 1992.
Hypothesis

It is hypothesized that there are meaningful positive effects of eighth grade parental involvement indicated by student/parent communications concerning students' academic lives and student/parent report of parental aspirations for their children's future educational attainment on students' mathematics achievement at eighth, tenth, and twelfth grade levels. It is further hypothesized that these effects not only operate directly, but also indirectly through intervening variables of mathematics achievement measured at eighth, tenth, and twelfth grades.
Chapter 2

Methodology

This study used data from the National Longitudinal Study of 1988 (NELS:88) base year, first follow-up with data collected in 1990, and second follow-up with data collected in 1992. Using data from the base year, first follow-up and second follow-up, it was possible to assess the effects of parental involvement measured in the eighth grade on mathematics achievement for the same cohort of students in the eighth, tenth, and twelfth grade. Analyses were conducted using structural equations modeling. Structural equations modeling requires the researcher to make explicit the theoretical causal model between independent and dependent variables. While path analysis establishes path coefficients, structural equations methods focus on latent variables defined using factor analysis of multiple indicators for some or all constructs. Of interest are the path coefficients between latent variables. Factor analysis of the constructs provides error free estimates of the constructs presumed to be causally linked thereby providing path coefficients unbiased due to measurement error.
Data Source and Subjects

The National Longitudinal Study of 1988 (NELS:88) base year, first follow-up, and second follow-up are data sources for this research. NELS:88 is the third in a series of Nationally representative longitudinal studies from the National Center for Educational Statistics (NCES) under direction of the U.S. Department of Education. NELS:88 was preceded by the National Longitudinal Study of the High School Class of 1972 (NLS-72) and High School and Beyond in 1980 (HS&B). NELS:88 was also the first NCES-sponsored longitudinal study to begin as early as the eighth grade. NELS:88 was designed as a nationally representative sample to provide trend data on critical developmental experiences with follow-up data collection procedures planned every two years, 1988, 1990, 1992, etc. The data and data codebooks were obtained from the Office of Educational Research and Improvement with raw data stored on CD-Rom in electronic codebook format (NCES, 1992).

Base year data collected in 1988 used a two-stage stratified probability sample with 1,734 schools randomly selected in the first stage. An average of 24 students per school were randomly selected to complete the second stage of data collection (NCES, 1990). The principal
mode of student data collection consisted of self-administered questionnaires and a battery of four achievement tests. The NELS:88 base year final student sample consisted of 24,599 students. Parent data were obtained by administration of a questionnaire designed primarily to collect parental information on factors which influence both educational attainment and participation in educational activities (NCES, 1990). A completion rate of 93% was obtained for the parent questionnaires.

To insure sample balance, schools were stratified by region, urbanicity, and minority proportions. Oversampling of Hispanic and Asian or Pacific Island heritage was employed for policy analysis applications. Students were disqualified from the sample only if a school representative believed that the student was mentally handicapped, or had a physical or emotional problem that would seriously impede their ability to complete the academic testing and survey information or had a language barrier. NELS:88 first follow-up survey data were collected in 1990. It contains data from 20,706 individuals, including 18,221 participating students, 1,043 dropouts, and 1,442 first follow-up nonrespondents. The NLS:88 first follow-up file includes
17,424 panel members for whom both base-year and first follow-up data were available. Subjects were chosen based on availability of both base-year and first follow-up data. NELS:88 second follow-up survey data were collected in 1992. It consisted of 16,489 base year retained sample members who completed a questionnaire in all three waves of NELS:88--base year, first follow-up, and second follow-up. This population contains an under coverage bias of 5% of potential base year sample members as not included.

Sample members for the primary model analysis at the eighth grade level were chosen on the basis of completed questionnaire data in the base year, cognitive tests in 1988, and base year parent questionnaires (N=21,924). Sample members for the primary analysis at the tenth grade level were chosen on the basis of completed questionnaire data in the base year, cognitive tests in 1990, and base year parent questionnaires (N=15,410). Sample members for the primary analysis at the twelfth grade level were chosen on the basis of completed questionnaire data in the base year, cognitive tests in 1992, and base year parent questionnaires (N=12,099).
The Primary Model

The primary causal model is a fully recursive model and is characterized in Figure 1. The variables enclosed in ovals represent the latent variables or constructs of interest. Unenclosed variables are the measured or manifest variables consisting of items and composites of items from the parent and student data files. Arrows from latent variables to measured or manifest variables define the measurement portion of the model. The measurement model is essentially a confirmatory factor analysis of the latent variables presumed to cause the measured variables (Loehlin, 1992). The other short arrows pointing to the measured variables represent both measurement error and unique variance of the measured variable. It is reasoned that the curved arrow between the mathematics grades measured indicator of previous achievement and the mathematics achievement indicator acknowledge that the general previous achievement latent variable and the mathematics achievement latent variable share unique variance not otherwise explained in the model. The structural or causal portion of the model is represented by the arrows between enclosed latent variables. The structural model is analogous to a path analysis among the latent constructs. These latent
Figure 1
Primary Causal Model
constructs are stripped of unreliability providing estimates of "true" effect of one latent construct on another (Hayduk, 1987). If the model is valid, then the results of its analysis should provide unbiased estimates of the true effects of parental involvement on student mathematics achievement. The two headed arrow joining the latent variables ethnicity and family background represent correlations due to influences outside the model, although analyzed, will not be interpreted in this research. This same causal model was analyzed three separate times as the students were in the eighth, tenth, and, twelfth grade. A second model incorporating mathematics achievement assessed at eighth, tenth, and twelfth grade including all three measures in a similar causal model was also analyzed. This second model, subsequently referred to as the longitudinal model, and depicted in Figure 2, was incorporated to help better explain the effects of eighth grade parental involvement on students' mathematics achievement. It was reasoned that the process of mathematics achievement is cumulative and that parental involvement may act indirectly through previously attained mathematics achievement.
Figure 2
Longitudinal Structural Model
Selection of Variables

Variable selection is supported by previous research (Keith et al., 1993; Keith et al., 1986) logic, and statistical analysis. Ethnicity and family background were included in the model because they are commonly controlled background characteristics in investigations of school effects (Ethington & Wolfle, 1986). Previous achievement was included since intellectual ability, recommended for control in learning research was not included in the NELS:88 data set. Research suggests, however, that previous achievement is a suitable representative for intellectual ability in learning research (Alexander, Pallas, & Cook, 1981). Parental involvement and mathematics achievement were included as independent and dependent variables of primary interest.

Student, parent, teacher, and school codebooks on the NELS:88 data were studied to create most of the latent variables under consideration. Only parent and student data files were used to create the variables studied here. When multiple items were available to measure a construct of interest, composites were formed by combining items based on analysis of the constructs. Full descriptions of all latent variables including their corresponding measured variables, items selected, coding
procedures, and data source files are included in Appendix A. Mathematics achievement test scores obtained in 1988, 1990, and again in 1992 were used as manifest indicators of mathematics achievement.

Ordering of Variables

The ordering of variables in both the primary and longitudinal models is based on previous parental involvement research (e.g., Keith et al., 1993; Keith et al., 1986; Seginer, 1986), theories of parental involvement (e.g., Epstein, 1987b; Marjoribanks, 1983; Seginer, 1983), and logical and actual time precedence. It is reasoned that ethnicity and family background variables should occur first in the model since previous research and theory (Bloom, 1964) suggest they are stable before middle school. Placing previous achievement between relevant background variables and parental involvement acknowledges its mediating effect and is supported by previous research (Keith et al., 1993) and theory (Bloom, 1964). Mathematics achievement, ordered last in the model, is supported by previous research (Keith et al., 1993) and is bolstered by the longitudinal nature of the data. It is reasoned that data collection
in 1990 and again in 1992 chronologically justify the placement of these variables in both the primary and longitudinal models.

To help explain how parental involvement affects future mathematics achievement, two additional variables were added to the primary model as shown in Figure 2. Based on theory (Carroll, 1989), variables representing mathematics achievement between eighth and twelfth grades have been inserted. Carroll (1989) suggest that parental involvement may affect learning indirectly by operating through time variables. Since both mathematics achievement in 1988 and 1990 occur chronologically before mathematics achievement in 1992, perhaps reflecting more time studying mathematics, they are modeled as possible intervening or mediating variables. These variables are viewed as methods by which parental involvement may affect tenth and twelfth grade mathematics achievement indirectly.

Variables

A general description of the variables included in this study follow. The NELS:88 items chosen to define each variable as well as the exact wording of each item
is included in Appendix A.

Ethnicity

Ethnicity was measured in 1988 as a dichotomous variable with a single indicator coded 1 for white and Asian-American students and 0 for students from all other ethnic groups (African-, Hispanic-, and Native-American). This coding scheme allows for comparisons between academically majority and minority groups. The error of the measured variable ethnicity was fixed in LISREL (in the theta-delta matrix using LISREL jargon). It was estimated that about 10% of the variance in ethnicity is due to error.

Family Background

Family background is a latent socioeconomic status variable measured in 1988 indexed by parental educational level, parental occupational status, and family income (labeled ParEduc, ParOcc, and Income in Figure 1). Student reports of parental education and occupation were used when parent reports were missing. The parent survey provided most of the information for these measured
variables. For parent education and occupation, the higher value--whether from the student's mother or father--was used. The NELS:88 data tapes report occupations in categories. These categories are converted to occupational status scores using Census codes and the Duncan (1961) socioeconomic index scale which provide prestige scores for all census occupational codes updated in 1990 (NCES, 1990). Family income was based on parents' reports of the total family income. In this analysis, the natural logarithm of income was used to transform income to have variances comparable to the other observed variable variances and to correct for skewness (Hayduk, pp. 328-29).

Previous Achievement

Previous Achievement is a latent variable indexed by student grades self reported in the eighth grade. Learning research should control for previous learning, whether through measures of intellectual ability, aptitude, or previous achievement (Alexander, Pallas, & Cook, 1981; Walberg, 1986). Since NELS:88 did not include tests of intellectual ability, measures of previous achievement, grades since sixth grade in
English, mathematics, science, and social studies were included as measures of previous achievement. Research supports the use of grades as an adequate measure of previous achievement (Walberg, Fraser, & Welch, 1986). Although the meaning of grades may vary from class to class and school to school, making them less reliable than achievement test scores, grades may also be a more valid measure of learning than test scores (Keith et al., 1993). Grades are more content specific than are most achievement tests (Wentzel, 1989) and provide a more continuous measure of student progress since they are given throughout the school year (Pehrmann et al., 1987). Grades are more sensitive measures of learning and may be improved more quickly through increased effort and motivation (Natriello & McDill, 1986). Grades are also more important measures of learning; grades, not test scores, are generally used in decisions to promote students to the next grade level.

Parental Involvement

Parental involvement is a latent construct measured in eighth grade and indexed by two manifest variables, educational aspirations and parent-child communication.
The manifest variable, educational aspirations (labeled Aspire in Figure 1), included parents' reports of their educational aspirations for their child's eventual educational attainment. Items included responses to the question "How far in school do you expect your eighth grader to go?" Educational aspirations also included students' perceptions of their parents' educational aspirations using fathers' (or male guardians) and mothers' (or female guardians) responses. Items included responses to the question "How far in school do you think your father and mother want you to get?" Since it is unknown whether actual parental involvement or student perceptions of parental involvement are more important for learning (Keith, 1991), information from both parents and students was used. For consistency, each parental involvement composite was weighed to be 50% student report and 50% parent report.

The Parent-Child Communications manifest variable (labeled Talk in Figure 1) was designed to measure the amount of communication between parents and students about school and school related activities. It included students' ratings of the frequency with which they discussed with their parents school activities and things studied in school, as well as the extent to which they
talked with their parents about planning for high school. A parents’ rating of the frequency of discussions about school and future school plans was also included.

Mathematics Achievement

Mathematics Achievement is a latent variable with data collected for the same cohort of subjects in the eighth, tenth, and twelfth grades. Achievement criterion data were collected in the base year, first follow-up, and second follow-up National Longitudinal Study of 1988. Mathematics Achievement (labeled Math Achievement in Figure 1), is indexed by a single indicator or measured variable for each mathematics achievement observed score. These observed variables consisted of mathematics achievement test scores based on a short standardized mathematics tests developed for NELS:88 by the Educational Testing Service and were similar to those used with previous NCES data sets. Base year, first follow-up and second follow-up mathematics cognitive tests all consisted of 40 item, 30 minute tests with slightly different content coverage. The base year mathematics test consisted of quantitative comparisons and other questions assessing mathematical knowledge
(NCES, 1990). The first follow-up mathematics tests assessed both simple mathematical application skills as well as more advanced skills of comprehension and problem solving. Test items included word problems, graphs, quantitative comparisons, and geometric figures. Three versions of the mathematics test were developed for the first follow-up, varying in the level of difficulty (NCES, 1992). The second follow-up mathematics test items included word problems, graphs, equations, quantitative comparisons, and geometric figures. Some questions could be answered by simple application of skills or knowledge, others required the student to demonstrate a more advanced level of comprehension and/or problem solving (NCES, 1994). Reliability coefficients for the three mathematics cognitive tests over the base year, first and second follow-up surveys were .89, .93, and .94 respectively (NCES, 1995). These single indicators were converted to z-scores and, for purposes of this analysis, assigned reliabilities of 1.00.
Chapter 3

Results and Discussion

Data were collected from students and their parents at two year intervals from the base year, first follow-up, and second follow-up of the National Educational Longitudinal Survey of 1988. The data were obtained from the Office of Educational Research and Improvement in CD-ROM format and were used to form latent variables included in two different models of eighth grade parental involvement effects on mathematics achievement. The first, or primary model was analyzed three separate times to estimate the effects of eighth grade parental involvement on mathematics achievement for the same cohort of students at the eighth, tenth, and twelfth grade levels. The second model used the same three measures of mathematics achievement in a longitudinal model. This model included mathematics achievement measured at two year intervals incorporating all three mathematics achievement measures in a single model. The data were analyzed with SPSS-PC to create Pearson product-moment correlation coefficients and standard deviations for input into LISREL8 (1993).
Since the units of measure of many of the observed variables were arbitrary and irrelevant, correlation matrices were analyzed for all models and standardized solutions estimated (Joreskog & Sorbom, 1989, p. 19). The theoretical full LISREL model for the primary model is pictured in Figure 1 and that for the longitudinal model in Figure 2. The full primary model analyzed at eight, tenth, and twelfth grades are depicted in order in Figures 3, 4, and 5 with corresponding structural model analyses in Figures 3A, 4A, and 5A. Subjects for all primary model analyses were based on completed student questionnaires, cognitive tests, and parent data in the base year resulting in eighth, tenth, and twelfth grade primary model sample sizes of 21,924, 15,410, and 12,099, respectively. Subjects for the longitudinal model were selected on availability of completed base year questionnaires, parent data, and cognitive test results in 1988, 1990, and 1992. This selection procedure resulted in a smaller sample size for the longitudinal model, 11,692, about 3% less than the twelfth grade primary model sample size. The full longitudinal model analyzed is pictured in Figure 6 with the structural model analyzed in Figure 6A. Fit statistics for all models analyzed are included in Figures 3 through 6A.
Figure 3
8th Grade Primary Model
Figure 3A
8th Grade
Primary Model
(Structural)

Chi-Squared = 974.42
DFV = 44.404 p = .133
DF = 35 N = 21,924
TLI = .9853
BBI = .9777
AGFI = .9850
RMR = .0175
Figure 4
10th Grade
Primary Model
Figure 5
12th Grade Primary Model
Figure 5A
12th Grade Primary Model (Structural)
Figure 6A
Longitudinal Model
(Structural)
Chi-square is an often discussed fit statistic in analyses of causal models. Chi-square is a measure of overall fit of the model to the data; it measures the difference between the sample correlation (covariance) matrix and the fitted correlation (covariance) matrix. The chi-square statistics in Figures 3, 4, and 5 for the primary model at eighth, tenth, and twelfth grade [974.42 (p=0.0), 653.143 (p=0.0), 545.405 (p=0.0) respectively] as well as that for the longitudinal model [555.371 (p=0.0)] in Figure 6 seem large. It is well known, however, that the quantitative value of chi-square is very dependent on sample size; with large sample sizes such as those used here, (range N=21,924 to N=11,692) tiny differences in the sample and fitted matrices can lead to a significant chi-square, thus suggesting the rejection of good models (Bentler & Bonett, 1980; Marsh, Balla, & McDonald, 1988). Another chi-square fit statistic less dependent on sample size, the Differential Fit Value (DFV) is suggested by Muthen (1989). This simple approach uses a standard sample size of 1,000 to calculate chi-square. The DFV statistics for the primary model at eighth, tenth, and twelfth grade [44.404 (p=.133), 42.345 (p=.184), 45.037 (p=.119) respectively] as well as that for the longitudinal model [47.457 
(p=.373)] all suggest good fit. Other indices of fit have also been developed which may be suitable with large samples. Two such indices, the Tucker-Lewis Index (TLI; Tucker & Lewis, 1973) and the Bentler-Bonett Index (BBI; Bentler & Bonett, 1980) each compare the chi-square for the considered model with that from a null model where the constructs are assumed to be statistically independent. Both the BBI and TLI indices are designed to be independent of sample size; for both, values approaching 1.00 suggest a good fit of the model to the data. Tucker-Lewis Indices (ranging from .998 to .991) and Bentler-Bonnet Indices (ranging from .979 to .985) for the primary and longitudinal models both suggest good fit of the models to the data. The AGFI, the adjusted goodness of fit index, also approaches 1.00 as the fit of the model improves. The AGFI measures how much better the model fits as compared to no model at all and does not depend on sample size explicitly (Tanaka & Huba, 1985). AGFI indices of .985 for the primary model at all three grade levels as well as the longitudinal model provide further evidence of the good fit of the models to the data. When correlation matrices are analyzed, as was done in this research, perhaps the most intuitively revealing fit index is the root mean square residual.
(RMR); this value represents the average difference of the predicted correlation matrix from the matrix calculated from the data. Since correlation matrices were analyzed for this study, root mean square residual values can be interpreted directly. RMR values ranged from .017 to .018 for both the primary and longitudinal models. This suggests that the correlations generated by both models differ, on average, from the actual correlations by about .0175.

Given a good fit of the models, the models can now be interpreted. Although many relationships among the variables exist, the variables of main interest in this research are parental involvement and mathematics achievement. Model interpretation, therefore, will concentrate mainly on the direct and indirect effects on mathematics achievement and parental involvement.

Analysis of the Primary Model

The means, standard deviations, and correlations among all of variables at all three grade levels for the primary model are listed respectively in Tables 1, 2, and 3. Analyses of standardized direct and indirect effects of variables in the primary model are listed in Tables 4 and 5 along with their corresponding standard errors.
Table 1
Eighth Grade Students
Variable Correlations, Means, and Standard Deviations
(Primary Model)

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Note. N = 21,924. Minimum pairwise N = 17,010
### Table 2

Tenth Grade Students

Variable Correlations, Means, and Standard Deviations

(Primary Model)

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Note. N = 15,410 Minimum pairwise N = 11,643
### Table 3

**Twelfth Grade Students**

*Variable Correlations, Means, and Standard Deviations*  
*(Primary Model)*

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Note. Standardized coefficients are listed with standard errors beneath in parentheses.
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**Note:** Standardized coefficients are listed with standard errors beneath in parentheses.
All factor loadings at eighth, tenth, and twelfth grades were significant and of the same expected general sign and magnitude. The standardized structural or path coefficients at all three grade levels are depicted respectively in Figures 3A, 4A, and 5A.

Direct, Indirect, and Total Effects on Mathematics Achievement in the Primary Model

As seen in Table 4, the strongest direct influence on mathematics achievement at all three grade levels in the primary model was previous achievement with standardized path coefficients of .317, .335, and .329 at eighth, tenth, and twelfth grades; this unsurprising result suggests that the strongest influence on current achievement is previous achievement. Family background had the next most powerful direct effect on mathematics achievement for all three grade levels with respective standardized path coefficients of .212, .190, and .218. Of more interest in this research are the effects of parental involvement on mathematics achievement. Parental involvement effects on mathematics achievement had the next largest direct effects, .168, .190, and .194. These standardized path coefficients suggest that parental involvement does indeed have a moderate
significant influence on eighth, tenth, and twelfth grade mathematics achievement as measured by eighth, tenth, and twelfth grade performance on standardized mathematics tests. Although ethnicity had the weakest direct effect on mathematics achievement with coefficients of .166, .157, and .148 by grade order, these effects are moderate and significant. The analysis of total effects for the primary model, expressing total effects as the sum of direct and indirect effects is also found in Table 4. The most powerful indirect effects on mathematics achievement at all three grade levels was family background with respective values of .267, .291, and .286; these effects were of the same general sign and magnitude. Ranking next in potency were the indirect effect of previous achievement on mathematics achievement with considerably smaller, but meaningful values, .076, .083, and .087 by grade order. The indirect effects of ethnicity on mathematics achievement were small, negative, and non-meaningful with successive values of -.023, -.031, and -.032 (Pedhazur, 1982, p. 617).

The most powerful total effect on mathematics achievement was family background with large standardized total effects of .479, .480, and .504 by grade level. Previous achievement’s total effects on mathematics
achievement ranked next in potency with large standardized total effects of .393, .418, and .414. The total effects of ethnicity on mathematics achievement were comparable to their direct effects with values of .143, .126, and .117 by grade level.

Direct, Indirect, and Total Effects on Parental Involvement in the Primary Model

As seen in Table 5, both family background and previous achievement have large (Pedhazur, 1982, p. 617) direct effects on parental involvement with family background largest. The standardized direct effects of family background on parental involvement by grade level were large, .627, .624, and .621.; generally higher socio-economic family background measured by parents’ occupational status, family income, and parents’ education had an expected large positive effect on the degree of parental involvement in their children’s academic lives. The direct effects of previous achievement on parental involvement were also large, .453, .436, and .441.; parents of children with better academic performance seem more likely to be involved than those of children with poorer previous academic performance. The direct effect for ethnicity on parental
involvement were significant, negative, and substantial, -.223, -0.222, and -.205; it appears that parents and students from ethnic minorities report more involvement than those from majority ethnic groups.

Table 5 shows that although comparable in magnitude to the direct effects, the indirect effects of family background on parental involvement were smaller, although substantial, with respective values of .187, .180, and .177. Family background seems to influence the degree of parental involvement depending on the students’ previous academic achievement. The indirect effects of ethnicity on parental involvement as it operates through previous achievement were small and non-meaningful, .017, .012, and .008, by grade order. The analysis of total effects in Table 5 shows large values for family background’s effects on parental involvement, .813, .804, and .798 respectively. Family background had a much greater effect on parental involvement than either ethnicity or previous achievement. The total effects of ethnicity (coded 1 for White and Asian, 0 for Other) on parental involvement were comparable in both sign and magnitude to the direct effects, -.206, -.210, and -.196.
Analysis of the Longitudinal Model

A second model, the longitudinal model, in which all three measures of mathematics achievement were included was also analyzed. The variable correlations, means, and standard deviations are listed in Table 6. Direct, indirect, and total effects on mathematics achievement in eighth, tenth, and twelfth grades are listed respectively and separately in Tables 7, 8, and 9. Direct, indirect, and total effects of ethnicity, family background, and previous achievement on parental involvement are included in Table 10. The longitudinal model is depicted as a full standardized LISREL model in Figure 6 and also with standardized, structural path coefficients only in Figure 6A. Since diagrammatic complexity could cause difficulty distinguishing the many path coefficients from standard errors if included in Figure 6A, the standard errors of these standardized path coefficients are listed in Tables 11 and 12. All factor loadings and path coefficients were statistically significant except for the effect of ethnicity on previous achievement with a t-value of 1.5175.
Table 6
Longitudinal Model
Variable Correlations, Means, and Standard Deviations

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Standardized Variable Correlations

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FAMILY VARIABLES

| FAMILY INCOME | 1.0000 | MEANS | 10.1436 | S. D. | .9122 |

Note: N = 12,059 Minimum pairwise N = 8,963
Table 7
Direct, Indirect, and Total Effects on Eighth Grade Mathematics Achievement
(Longitudinal Model)

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Note. Standardized coefficients are listed with standard errors beneath in parentheses.
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(Longitudinal Model)

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Note. Standardized coefficients are listed with standard errors beneath in parentheses.
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Note. Standardized coefficients are listed with standard errors beneath in parentheses.
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Direct, Indirect, and Total Effects on Parental Involvement
(Longitudinal Model)

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Note. Standardized coefficients are listed with standard errors beneath in parentheses.
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<th>Mathematics Achievement 1988</th>
<th>Mathematics Achievement 1990</th>
<th>Mathematics Achievement 1992</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Previous Achievement</strong></td>
<td>0.4340</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
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<td>Parental Involvement</td>
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<td>0.2888</td>
<td>0.0827</td>
<td>0.0179</td>
<td>0.0305</td>
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<td>Mathematics Achievement</td>
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<td>0.1242</td>
<td>0.3874</td>
<td>0.0143</td>
<td>0.0235</td>
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<tr>
<td>Mathematics Achievement</td>
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<td>0.0761</td>
<td>0.0642</td>
<td>0.0102</td>
<td>0.0169</td>
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</table>

Note: Standardized coefficients are listed with standard errors beneath in parentheses.
### Table 12
Direct Effects and Standard Errors of Exogenous Variables on Endogenous Variables

<table>
<thead>
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<th>Variable</th>
<th>Ethnicity</th>
<th>Background</th>
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<tr>
<td>Parental Involvement</td>
<td>-.2104</td>
<td>.6236</td>
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<tr>
<td>Previous Achievement</td>
<td>.0176</td>
<td>.3960</td>
</tr>
<tr>
<td>Math Achievement 1988</td>
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<td>.1541</td>
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<tr>
<td>Math Achievement 1990</td>
<td>.1055</td>
<td>.1536</td>
</tr>
<tr>
<td>Math Achievement 1992</td>
<td>.0347</td>
<td>.0536</td>
</tr>
</tbody>
</table>

Note. Standardized coefficients are listed with standard errors beneath in parentheses. Only Ethnicity’s effect on Previous Achievement was not statistically significant with T-Value=1.5173.
Direct, Indirect, and Total Effects on Mathematics Achievement in the Longitudinal Model

As seen in Table 7, previous achievement had the largest direct effect on eighth grade mathematics achievement with a standardized path coefficient of .287. This expected result suggests that children with higher previous academic achievement perform better on standardized mathematics tests than those of lower previous academic achievement. Family background’s direct effects on eighth grade mathematics achievement was a moderate .154; it seems, again as expected, that children from higher socio-economic backgrounds perform better on standardized mathematics tests than from lower socio-economic groups. Ethnicity had the next largest direct effect on mathematics achievement at eighth grade, .120. Although small, parental involvement’s direct effect on eighth grade mathematics achievement was significant and meaningful, .083. The indirect effects of family background on eighth grade mathematics achievement was somewhat larger than the direct effects, .179. The indirect effects of previous achievement on eighth grade mathematics achievement were a small non-meaningful .034. as were the indirect effects of ethnicity, -.012. The total effects on eighth grade
mathematics achievement consisted mainly of almost equal indirect effects of family background and previous achievement with large values of .333 and .332 respectively while the total effects for ethnicity was a moderate .109.

In the longitudinal model for tenth grade mathematics achievement, listed in Table 8, again the largest direct effects on mathematics achievement were previous achievement and family background with respective values of .254 and .154, again an expected result. Parental involvement and ethnicity had the next most potent meaningful effects of .124 and .106. Mathematics achievement at eighth grade had a small, although meaningful, direct effect on tenth grade mathematics achievement, .064. The largest indirect effects on tenth grade mathematics achievement were those for family background, .328, more than twice the direct effect. Previous achievement's indirect effects on tenth grade mathematics achievement in the longitudinal model were next most potent at .178; again, the influence of previous academic achievement on subsequent mathematics achievement seems the norm. Parental involvement and ethnicity's indirect effects on tenth grade mathematics achievement were small, .032 and .021 respectively. As
before, family background and previous achievement had the largest total effects on tenth grade mathematics achievement with respective values of .482 and .433; apparently family background and previous achievement are consistently large and important constructs influencing students' mathematics achievement. Parental involvement and ethnicity had the next largest total effects on tenth grade mathematics achievement in the longitudinal model with comparable values, .156 and .123; again, parental involvement had a meaningful, moderate influence on mathematics achievement. The direct effects on mathematics achievement at twelfth grade are listed in Table 9. The largest direct effect on mathematics achievement at twelfth grade was that of mathematics achievement in tenth grade, .711. In the longitudinal analysis, it appears that the most influential force in twelfth grade mathematics achievement is the most recent level of mathematics achievement. Parental involvement, mathematics achievement in eighth grade, previous achievement, and family background, in rank order from smallest to largest, had small meaningful direct effects on twelfth grade mathematics achievement, .076, .062, .059, and .054. The small meaningful direct effect of parental involvement on twelfth grade mathematics
achievement (.076) suggests that the moderate effects of parental involvement on mathematics achievement in all three grades are mediated by mathematics achievement measured in the tenth and twelfth grades when analyzed longitudinally. The effect of ethnicity on twelfth grade mathematics achievement was a small non-meaningful .035. Family background and previous achievement had the most powerful total effects on twelfth grade mathematics achievement, except for mathematics achievement in tenth grade, with standardized path coefficients of .501 and .420, again, no surprise. Parental involvement and mathematics achievement in eighth grade had the next most powerful total effects with equal path coefficients of .336. Again this result suggest the importance of recent previous mathematics achievement on future mathematics achievement test scores as well as parental involvement effects. The total effects for ethnicity ranked last in potency with a value of .117 with most of this effect being indirect.

Direct, Indirect, and Total Effects on Parental Involvement in the Longitudinal Model

As seen in Table 10, the most potent direct effect on parental involvement in the longitudinal model was
that of family background, .624. As before, parents of students from higher SES groups appear more involved than those from lower. Previous achievement also had an expected powerful effect, .430. Ethnicity had a moderate negative effect on parental involvement with a standardized path coefficient of -.210; it appears that parents and students from ethnic groups typically labeled as disadvantaged (African-, Hispanic-, and Native-American descent) report more involvement than those from other ethnic groups. The indirect effects on parental involvement of family background in the longitudinal analysis was a modest but meaningful .170 and that for ethnicity a small non-meaningful .008. The constructs with largest total effects on parental involvement were family background and previous achievement with respective coefficients of .794 and .450. As before, ethnicity’s effect on parental involvement was negative and substantial, -.203, again suggesting that minority parents are more likely to report parental involvement in their children’s academic lives than majority groups when controlling for family background and previous achievement.
Conclusions

As hypothesized, eighth grade parental involvement as indicated by parental aspirations for their child's future education and parent/child communication concerning school related topics is an important positive influence on students mathematics achievement test scores at eighth, tenth, and twelfth grades. Although many of the same general conclusions can be drawn from the analyses of the primary and longitudinal models, incorporation of mathematics achievement measures as intervening variables in a longitudinal design helps explain better the effects of parental involvement at the middle school level on future mathematics achievement test scores.

Mathematics achievement appears to be a cumulative process depending heavily on the level of mathematics achievement previously attained. This research as well as other research bolster the idea that one of the most salient influences on subsequent mathematics achievement is previous mathematics achievement (Ethington & Wolfe, 1986). A general application of this result for practitioners seems apparent; students may benefit by being exposed to more and increasingly more demanding
mathematics if this cumulative achievement process in math is to continue positively.

The measure of mathematics achievement studied is also important. Mathematics achievement in this research was measured by standardized mathematics test scores; other research, however, has indicated no effect of parental involvement on achievement test scores of secondary school level students (Keith, 1991; Keith et al., 1986, Natriello & McDill, 1986). The different definitions of parental involvement, data collection methods, methodology, and differences in criteria may help explain such inconsistencies.

Previous research (Keith et al., 1993) has found negative effects of ethnicity on parental involvement indicating more involvement for minority groups. These consistent negative direct effect of ethnicity on parental involvement were present in both the primary model at all three grade levels and also in the longitudinal model. The effects of ethnicity, (coded 1 for white and Asian and 0 for other minority groups) suggests that parents and students from ethnic groups often labeled as disadvantaged (African-, Hispanic-, and Native-American descent) appear more involved than those from "advantaged" ethnic groups when controlling for
relevant background variables. Perhaps traditionally labelled minority groups are putting forth a conscious effort to help compensate for either perceived or actual shortcomings encountered by their children in our educational system.

Family background had by far the strongest effects on parental involvement in this research. It appears that family background does influence mathematics achievement. This large total effect seems to operate largely as an indirect effect through subsequent mathematics achievement. Parents from higher socioeconomic backgrounds generally appear more involved in the academic lives of their children and that involvement, in turn, produces higher mathematics achievement. It may be that this type of parental involvement is a contributing factor for high socioeconomic status students achieving more highly than low.

Parental involvement is not a simple relationship causing increased student achievement by offsetting the deleterious effects of low socioeconomic status. For efforts to increase parental involvement as defined in this study to compensate for a socioeconomic related mathematics achievement gap, increased parental
involvement would have to be greater for low socioeconomic groups than high. It may be that parental involvement has diminishing returns for learning outcomes or that these effects are stronger on the achievement of low than high socioeconomic groups if differences due to SES can be offset by increased parental involvement. This could be investigated in future research by testing for curvilinear relationships and possible interactions between varied definitions of parental involvement and socioeconomic background variables as they affect achievement (Keith et al., 1993).

Socioeconomic influences, ethnicity, and student ability (defined in this study as previous achievement indicated by student' self reported grades) do not readily lend themselves to manipulation and are relatively stable by the time a child reaches eighth grade. More easily changed are those things we can directly alter. Unlike many influences on academic achievement, parental involvement defined as student/parent communications and parental aspirations for their child's education is potentially manipulable. Perhaps conscious efforts by parents, teachers, administrators, and even students themselves can enhance parents' positive influence on student achievement in
general, mathematics in particular. Perhaps programs designed to assist parent/child communications and influence increased contact between parents and secondary school age children could offer possible avenues of improvement. Programs designed to teach parents and students how and why to communicate more effectively especially concerning parent aspirations for their children's future education may need more emphasis. In fact, programs designed to build family interaction and student academic progress without duplicating school activities already exist. Many such programs, including the Home and School Institute Program and the Houston Fail-Safe program were described in a survey of home-school partnership efforts in the upper elementary and secondary schools in the 24 largest American cities (Collins, Moles, & Cross, 1982).

This research helps shed light on some unanswered questions concerning the effects of parental involvement—its effects on eighth, tenth, and twelfth grade mathematics achievement but many questions remain. Future research will be needed to determine how parental involvement effects as defined in this study can be better understood. There are unanswered questions which are important to practitioners. How might parental
aspirations best be conveyed to students? How can educators both inform and help parents with strategies to aid this process? Also what other involvement strategies might educators and parents utilize to improve student learning? The myriad of different definitions of parental involvement also need further investigation and their importance more closely scrutinized. This research defined parental involvement using both student and parent reports of student-parent communication and parental aspirations for their child's education. It seems important to investigate whether actual parental involvement as reported by parents or perceived parental involvement as reported by students are different, and if so, if this difference is constant across criteria of learning, age of the student, and subject area. Other questions include the investigation of racial and gender differences in the effects of parental involvement on students' academic performance. Whether grades or achievement test used as learning criteria produce differing results is also of future interest.

The results reported here must, of course, be interpreted cautiously. Structural modeling, while offering a powerful and appropriate method for the analysis of nonexperimental data, certainly has its
drawbacks. The inferences made here do not demonstrate cause and effect with the same power and rigor of a true experimental study. The neglected third variable problem inherent in causal analyses of nonexperimental data is certainly not circumvented by the methodology applied for this study. The conclusions reached here, therefore, are constricted by the theory applied and previous research that was used to construct the models. However, given the adequacy of the models and the measurement of the constructs used in this study, the results appear widely generalizable. The very nature of parental involvement is nonexperimental and limits the applicability of true experimental studies. Causal modeling and latent structural path analysis offer powerful and sophisticated methods for such analyses that lend themselves well to nonexperimental data analysis.

Despite these cautions, this research seems important both theoretically and practically. It suggests that parental involvement measured in the eighth grade is an important influence on the mathematics achievement of students at eighth, tenth, and twelfth grades. That this type of parental involvement contributes to increased mathematics achievement and this contributing effect seems to endure throughout high
school draws attention to the importance of parent/child communication about school related topics and parents’ aspirations for their children’s educational attainment. Parents, teachers, administrators, and even the students themselves are all capable of enhancing parent/child communication on academic aspirations and performance, but the biological fact that middle school and high school students are experiencing drastic physiological changes and increasing social pressures may hamper such efforts.

Although the definition of parental involvement studied in this research may be studied under different rubrics or names, this research is consistent with previous research with identical variable names (e.g., Keith et al., 1993).

Both theoreticians and practitioners may draw on the conclusions reached here in increasingly important efforts to enhance learning in mathematics and perhaps other subjects through parental involvement. It appears that the role of school psychologist and counselors may help circumvent these natural barriers to parent/child communications.
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Appendix A

This appendix shows the composition and coding of each measured variable in both the primary and longitudinal model and the corresponding latent variable or construct. Also included is the file (Parent or Student) from which the items were drawn. Most measured variables are indicated by composites of several items. When dissimilarly coded items were combined to form composite indicators, they were first converted to z-scores to insure equal weighing. Questions asked of students about parents also pertained to guardians (for example, questions about mothers were worded "your mother [or female guardian]..."), Questions asked of parents about their spouse were generally worded "you or your spouse/partner."

1. Ethnicity: Ethnicity is indicated by a measured variable, ethnicity. The measured variable is a dichotomous variable coded 1 for White and Asian, and 0 for Black, Hispanic, and Native American. An assumed measurement error of 10% for purposes of these analyses is incorporated into the model construction. (NELS:88, Parent file)

2. Family Background: The latent variable Family Background is indicated by three measured variables, parent occupation, parent education, and family income. Highest status is used and student data is used if missing. Parent
Education includes respondent and spouse education with highest education level used. Parent education is coded 1=Did not finish high school to 6=MD, PhD, etc. Student data is be used if missing. The measured variable Family income utilized total family income for 1987 recoded to the midpoint of categories (e.g., 12500=$10,000 to $14,999). Range was 0 (None) to 250,000 ($200,000 or more). (NELS:88, Parent file; NELS:88 Student file)

3. Previous Achievement: The latent variable Previous Achievement is indicated by four measured variables, English, math, science, and social studies. All four measured variables used students' self reported grades. The English measured variable used grades in English, grades 6 to present. The math measured variable used grades in math, grades 6 to present. The science measured variable used grades in science, grades 6 to present, and the social studies measured variable used grades in social studies, grades 6 to present. All grades were coded, 1=mostly below D to 5=Mostly As. (NELS:88, Student file)

4. Parental Involvement: The latent variable Parental Involvement is indicated by two measured variables, communication and aspirations. All parental involvement measured variables are weighed to be based 50% parent response and 50% student response. The communication
measured variable is a composite indicator indexed by 8
items, 5 from the student file, and 3 from the parent file.
Student file items include: Discusses programs at school
with parents, coded 1=not at all, 2=once or twice, 3=3 or
more times; Discusses school activities with parents, coded
1=not at all, 2=once or twice, 3=3 or more times; Discusses
things studied in class with parents, coded 1=not at all,
2=once or twice, 3=3 or more times; Talk to father about
planning high school program, coded 0=not at all to 3=3 or
more times; Talk to mother about planning high school
program, coded 0=not at all to 3=3 or more times. (NELS:88,
Student file) Parent file items include: How often talks
to child about school experiences, coded 1=not at all to
4=regularly; How often parent talks to child about high
school plans, coded 1=not at all to 4=regularly; How often
parent talks to child about post high school plans, coded
1=not at all to 4=regularly. (NELS:88, Parent file)

The educational aspirations measured variable included
three items, one from the parent file, and two from the
student file. Student file items included responses to the
questions; How far in school does your father want you to
go? Coded 1=less than high school to 6=a doctorate.
(NELS:88 Student file); How far in school does your mother
want you to go? Coded 1=less than high school to 6=a

5. Mathematics Achievement 1988: The Mathematics Achievement 1988 latent variables is indexed by a single indicator, the mathematics standardized test score.
(Student file, NELS:88 base-year)

6. Mathematics Achievement 1990: The Mathematics Achievement 1990 latent variable is indexed by a single indicator, the mathematics standardized test score.
(Student file, NELS:88 first follow-up)

7. Mathematics Achievement 1992: The Mathematics Achievement 1992 latent variable is indexed by a single indicator, the mathematics standardized test score.
(Student file, NELS:88 second-follow-up)
VITA

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