DOCUMENT RESUME

ED 303 337 SE 050 295

AUTHOR	Miller, Jon D.
TITLE	The Origins of Interest in Science and Mathematics.
PUB DATE	Apr 88
NOTE	16p.; Paper presented at the Annual Meeting of the American Educational Research Association (New Orleans, LA, April 5-9, 1988).
PUB TYPE	Reports - Research/Technical (143) -- Speeches/Conference Papers (150)
EDRS PRICE	MF01/PC01 Plus Postage.
DESCRIPTORS	*Grade 7; Interests; Junior High Schools; *Longitudinal Studies; Middle Schools; *Science and Society; *Secondary School Mathematics; *Secondary School Science; *Student Attitudes; Student Interests; Technological Advancement; Technology
IDENTIFIERS	*Longitudinal Study of American Youth

ABSTRACT

Children in the United States and other industrialized countries grow to adulthood in an age of science and technology. Satellites, television sets, microprocessors, and microwave ovens are as common as the sun and trees. The context of socialization to adulthood in the last half of the 20th century is far different in kind than any previous socialization environment. It is likely that the socialization environment for our grandchildren will be characterized even more strongly by science and technology. Despite these changes in the socialization environment, there has been little systematic study of the effects of growing up in a scientific and technological world on the formation of attitudes toward science and technology. Some commentators have claimed to have found alienation toward science and technology, while others think that it has captured the imagination of newer generations. The Longitudinal Study of American Youth (LSAY) is one effort to better understand the process of socialization and attitude development toward science and technology and citizenship. This paper presents the preliminary results from the LSAY base year 7th-grade data set to examine the origins of student interest in science and mathematics, using a set of multivariate log-linear models to examine the structure of parental and peer influences on the student's attitudes. (CW)

The Origins of Interest in Science and Mathematics

Jon D. Miller

Director
Public Opinion Laboratory
Northern Illinois University
DeKalb, Illinois 60115
815-753-0555

A paper presented to the 1988 annual meeting of the American Educational Research Association, New Orleans, Louisiana.

April 9, 1988

Socialization in an Age of Science and Technology

Children in the United States and other industrialized countries grow to adulthood in an age of science and technology. Satellites, television sets, microprocessors, microwave ovens are as common as the sun and trees. It is clear that the context of socialization to adulthood in the last half of the 20th century is far different in kind than any previous socialization environment. It is likely that the socialization environment for our grandchildren will be characterized even more strongly by science and technology.

Despite these changes in the socialization environment, there has been little systematic study of the effects of growing up in a scientific and technological world on the formation of attitudes toward science and technology. Some commentators have claimed to have found alienation toward science and technology, while others think that it has captured the imagination -- if not the mind -- of newer generations. It should be possible to resolve some of the confusion about the impact of science and technology on socialization through rigorous empirical study.

The Longitudinal Study of American Youth[1] (LSAY) is one effort to better understand the process of socialization and attitude development toward science and technology and citizenship. The LSAY builds upon a previous cross-sectional study by Miller, Suchner, and Voelker[2] and upon the relevant literature. The LSAY will follow a national sample of 7th-graders and a parallel sample of 10th-graders for the next four years, collecting data from the students, their parents, their teachers, and related school staff. The base year student data collection for the LSAY was completed in the Fall of 1987.

This paper will use the preliminary results from the LSAY base year 7th-grade data set to examine the origins of student interest in science and mathematics, using a set of multivariate log-linear models to examine the structure of parental and peer influences on the student's attitudes. The base year data set is still essentially a cross-sectional data set, but by building models that allow us to better understand current attitude structures, we will be better equipped to conceptualize and monitor the patterns of change that will emerge over the next years of the LSAY.

---

[1]The work reported in this paper is supported by National Science Foundation grant MDR-8550085. All of the analyses, opinions, and conclusions offered are those of the authors and do not necessarily reflect the views of the National Science Foundation or its staff.

[2]Citizenship in an Age of Science. New York: Pergamon Press. 1980.

The Measurement of Attitude toward Science and Mathematics

What do we mean by a student's interest in science or mathematics? The term has been used in a wide array of contexts, referring to interest in specific courses or texts to plans for an occupation or career. In the LSAY, we have measured each student's liking for science and mathematics, anxiety about those subjects, perceptions of utility, sense of competence, and a variety of attitudes toward specific courses. Interest in science or mathematics is, indeed, a complex construct.

For the purposes of this analysis, a student will receive a positive score on the Attitude toward Science Index for agreeing with the following statements:

I enjoy science.
I am good at science.
I usually understand what we are doing in science.
Science is useful in everyday problems.
Science helps a person think logically.
It is important to know science to get a good job.
I will use science in many ways as an adult.

and for disagreeing with the following statements:

Doing science often makes me nervous or upset.
I often get scared when I open my science book and see a page of problems.

Following a Likert procedure, a scale score was derived. For the model building analyses that are described below, this index was dichotomized into the top third and the bottom two-thirds. This procedure will allow us to explore the degree of association between a positive attitude toward science and various parental, peer, and demographic influences.

A similar set of items were used to measure Attitude toward Mathematics, except that the word mathematics was substituted for the word science in all of the items. This index was also scored using a Likert method and then dictomotized into the top third and the bottom two-thirds.

An examination of the distribution of 7th-grade students on these two indices indicated that a higher proportion of girls holds positive attitudes toward science than boys (see Table 1). The level of formal education to which a student aspires is strongly and positively associated with positive attitudes toward both mathematics and science. The level of parental education is strongly associated with attitude toward science, but only weakly associated with attitude toward mathematics.

In the model building reported in the next section of this paper, six additional variables are used that reflect the level and focus of parental and peer encouragement of the study of science. It is useful to review those measures now and to examine briefly their relationship to the student's attitude toward his or her science course.

Table 1: Percentage of 7th-Grade Students with Positive Attitudes toward Science and Mathematics.

	Positive Attitude toward ...		
	Mathematics	Science	N
All 7th-grade students	33%	34%	2620
Gender			
Male	32	30	1274
Female	34	38	1346
Student Educational Aspirations			
Less than baccalaureate	23	23	784
Baccalaureate	32	29	766
Graduate degree	44	48	801
Parental Education			
High school diploma or less	31	30	759
Some college	37	31	493
Baccalaureate or more	35	40	696
Parent Academic Push			
Low	29	26	1357
High	38	40	1263
Parent Science Push			
Low	31	28	2127
High	46	53	493
Parent Mathematics Push			
Low	30	28	1950
High	44	46	670
Peer Academic Push			
Low	29	28	1215
High	38	37	1405
Peer Science Push			
Low	31	31	2127
High	43	41	478
Peer Mathematics Push			
Low	33	29	2207
High	38	50	413

Parent Academic Push refers to general parental encouragement to value education and to do well in school. For this analysis, this variable was measured by the number of student agreements to the following statements:

My parents:
- insist I do my homework.
- tell me how proud they are when I make good grades.
- expect me to complete college.
- tell me how confident they are in my ability.
- often help me understand my homework.
- reward me for getting good grades.
- ask me a lot of questions about what I am doing in school.

This variable is positively associated with attitudes toward science and mathematics in the LSAY data.

Parent Mathematics Push refers to specific parental actions focused on or closely related to mathematics, in contrast to the more general academic encouragement measured above. For this analysis, this variable was measured by the number of student agreements to the following statements:

My parents:
- want me to learn about computers.
- have always encouraged me to work hard on math.
- buy me math and science games and books.
- expect me to do well in math.
- think that math is a very important subject.

This variable is positively and strongly associated with attitudes toward science and mathematics in the LSAY data.

Parent Science Push refers to specific parental actions focused on or closely related to science, in contrast to the more general academic encouragement measured above. For this analysis, this variable was measured by the number of student agreements to the following statements:

My parents:
- want me to learn about computers.
- have always encouraged me to work hard on science.
- buy me math and science games and books.
- expect me to do well in science.
- think that science is a very important subject.

This variable is positively and strongly associated with attitudes toward science and mathematics in the LSAY data.

Peer Academic Push refers to peer encouragement of school and learning generally. For this analysis, this variable was measured by the number of student agreements with the following statements:

Most of my friends:
- plan to go to college.
- are really good students.
- often help me with my homework.
- think I am a good student.

This variable is positively associated with attitudes toward science and mathematics in the LSAY data.

Peer Mathematics Push refers to specific peer encouragements of the study of mathematics. For this analysis, this variable was measured by the number of student agreements to the following statements:

Most of my friends:
- like math.
- do well in math.
- hope to become scientists, doctors, engineers, or mathematicians.
- know how to write computer programs.

This variable is positively associated with attitudes toward science and mathematics in the LSAY data.

Peer Science Push refers to specific peer encouragements of the study of science. For this analysis, this variable was measured by the number of student agreements to the following statements:

Most of my friends:
- like science.
- do well in science.
- hope to become scientists, doctors, engineers, or mathematicians.
- know how to write computer programs.

This variable is positively associated with attitude toward science course in the LSAY data.

Some Models to Predict Attitude toward Science and Mathematics

Models are abstractions of reality. Inherently, they are simpler than reality, but seek to abstract from the social world those forces, factors, actions, or attitudes that are related to -- causally or otherwise-- outcome attitudes or behaviors of interest to us. In this analysis, we are interested in better understanding the distribution of student attitudes toward science and mathematics displayed in Table 1, and we would like to understand the relative contribution of each of several parental and peer activities. For this purpose, we will utilize a set of log-linear logit models, using the techniques developed by Leo Goodman and described by Stephen Feinberg.

Beginning with attitudes toward mathematics among 7th-grade students, it is useful to look at the relative contribution of the student's gender, the parent's formal education, the educational aspiration of the student, the level of parent academic push, and the level of parent mathematics push. These are five variables that are often noted in traditional explanations of student attitudes toward courses.

The path model indicates that parental education and gender are associated with student educational aspirations (see Figure 1). The level of parental education is positively associated with the level of parent academic push and the level of parent mathematics push. Both the level of student educational aspiration and parent mathematics push are positively associated with the student's attitude toward mathematics. The absence of a direct path from either gender or parental education to math attitude indicates that the influence of these two variables is fully accounted for in the levels of student educational aspiration, parent academic push, and parent mathematics push. There is no residual direct influence on math attitude.

While this general structural understanding is helpful, it would be more useful if we could estimate the relative strength of each of the paths in the model and, thereby, better understand the relative influence of these variables. Fortunately, it is possible to utilize a set of log-linear logit models to develop estimates of the relative strength of the paths, and Table 2 includes a set of models relevant to the path model in Figure 1.

The total path model is comprised of three separate or submodels. Models 1, 2, and 3 estimate the paths from gender and parental education to student's educational aspiration. Model 1 calculates the total mutual dependence[3] available in that submodel and Model 2 calculates the mutual dependence accounted for by the relationship between gender and student's educational aspiration. Model 3 calculates the mutual dependence accounted for by the relationship between parental education and student's educational aspiration. The results indicate that parental education is substantially more influential in the development of student's educational aspirations than is gender.

Models 4, 5, and 6 estimate the paths from gender and parental education to parental mathematics push. The results indicate that parental education is positively and strongly associated with the level of parent academic push. There is a significant, but weaker, relationship between gender and the level of parent mathematics push. In the LSAY data, a slightly higher proportion of girls report a high level of parent mathematics push than boys and this relationship indicates that differential.

Models 7, 8, and 9 estimate the paths from gender and parental education to parental academic push. The results indicate that parental education is strongly and positively associated with parent academic push, but that there is no significant relationship between gender and parent academic push. This result would suggest that parents treat their sons and daughters equally in regard to general academic encouragement.

---

[3] Mutual dependence is a term suggested by Leo Goodman and is analogous to variance in interval analyses. The mutual dependence is the sum of the residual likelihood-ration chi-squares (without regard to sign) obtained when the estimated cell frequencies (based on the marginal distributions of the dependent and independent variables and on the associations among the independent variables) are subtracted from the observed cell frequencies. It should be noted that, unlike interval models, the total mutual dependence in a logit model reflects only the variation in cell populations for the variables included in the analysis — not for all possible explanatory variables.

Models 10 through 16 describe the relationships between each of the independent variables and attitude toward mathematics. The results indicate that student's educational aspiration and parent math push are the strongest predictors of positive attitudes toward science courses, with educational aspiration accounting for 24 per cent of the total mutual dependence in the model and parent math push explaining about 12 per cent of the mutual dependence. This result suggests that while general parental academic encouragement may foster positive attitudes toward schooling, it is specific parental encouragement of mathematics and of higher levels of educational achievement that fosters positive attitudes toward mathematics.

Turning to the issue of the influence of peers on attitude toward mathematics, the path analysis indicated that both parental education and gender were associated with peer academic push (see Figure 2), but that only gender was associated with peer mathematics push. The LSAY data indicated that 7th-grade boys were significantly more likely to report general academic encouragement from other students than were 7th-grade girls, but that 7th-grade girls were more likely to report peer math encouragement than were 7th-grade boys. Attitude to mathematics, however, was associated with student's educational expectations and peer academic encouragement. Peer mathematics encouragement did not have a significant residual relationship with math attitude when the other variables in the model were held constant (see Table 3).

Looking at the influence of parents and peers, it is possible to construct a final model of attitude toward mathematics that incorporates the strongest attributes of both models. This model included gender, parent's education, student's expected education, parent math encouragement, and peer academic push. The resulting path analysis indicated that student educational aspiration, parent math push, and peer academic push all had significant direct relationships with math attitude (see Figure 4). A set of logic analyses indicated that the strongest predictor of math attitude was student's educational aspiration, which accounted for 25 per cent of the total mutual dependence in the model (see Table 5). Parent math encouragement explained about 12 per cent of the mutual dependence.

In summary, these models suggest that 7th-grade student attitudes toward mathematics are significantly influenced by the student's educational aspirations. Students who expect to go to college or graduate school -- and many 7th-grade students are clear in that expectation -- are more likely to hold positive attitudes toward mathematics than students with lower educational expectations. A high level of parent math push enhances the odds of a positive attitude toward mathematics.

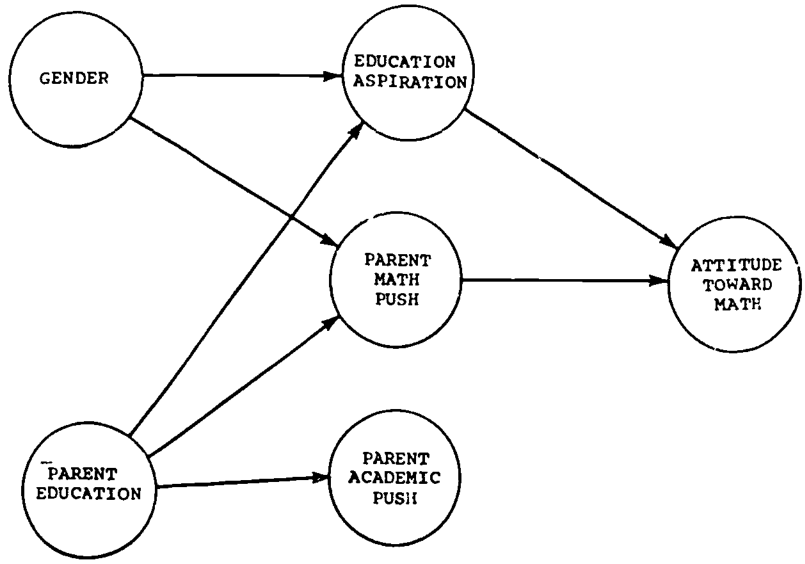

Figure 1: A Path Model to Predict Attitude toward Mathematics among 7th-Grade Students.

Table 2: Some Logit Models to Estimate the Strength of Selected Paths.

Model	Terms	d.f.	LRX^2	CMPD	P
1.	Total mutual dependence in GP, E.	10	198.8	--	.000
2.	Mutual dependence accounted for by GE.	2	22.3	.112	.000
3.	Mutual dependence accounted for by PE.	4	176.9	.890	.000
4.	Total mutual dependence in GP, M.	5	56.1	--	.000
5.	Mutual dependence accounted for by GM.	1	8.5	.152	.004
6.	Mutual dependence accounted for by PM.	2	47.3	.843	.000
7.	Total mutual dependence in GP, A.	5	39.9	--	.000
8.	Mutual dependence accounted for by GA.	1	.3	.008	.554
9.	Mutual dependence accounted for by PA.	2	34.6	.867	.000
10.	Total mutual dependence in GPEAM, Y.	71	214.3	--	.000
11.	Mutual dependence accounted for by GY.	1	3.5	.016	.063
12.	Mutual dependence accounted for by PY.	2	5.0	.023	.083
13.	Mutual dependence accounted for by EY.	2	51.2	.239	.000
14.	Mutual dependence accounted for by AY.	1	2.0	.009	.161
15.	Mutual dependence accounted for by MY.	1	25.9	.121	.000
16.	MD accounted for by all 5 main effects.	7	105.1	.490	.000

Legend:
d.f. degrees of freedom
LRX^2 Likelihood-Ratio Chi-Square
CMPD Coefficient of Multiple-Partial Determination

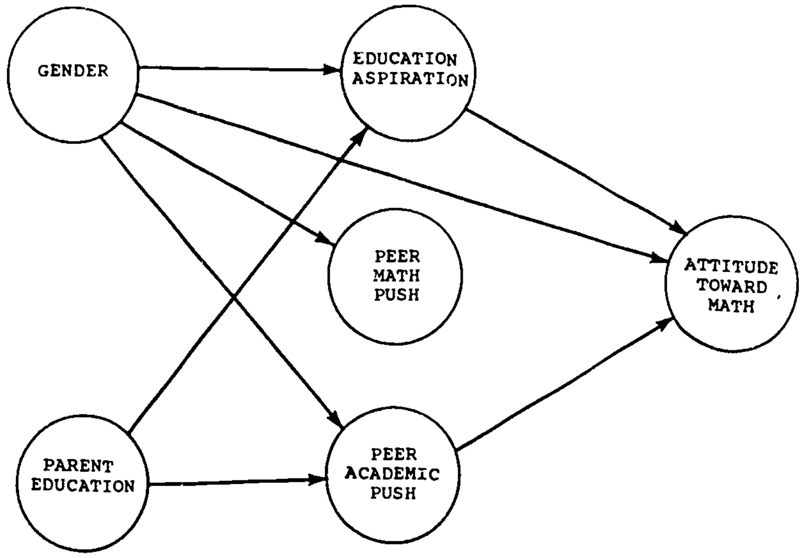

Figure 2: **A Path Model to Predict Attitude toward Mathematics among 7th-Grade Students.**

Table 3: **Some Logit Models to Estimate the Strength of Selected Paths.**

Model	Terms	d.f.	LRX^2	CMPD	P
1.	Total mutual dependence in GP, E.	10	198.8	--	.000
2.	Mutual dependence accounted for by GE.	2	22.3	.112	.000
3.	Mutual dependence accounted for by PE.	4	176.9	.890	.000
4.	Total mutual dependence in GP, M.	5	25.3	--	.000
5.	Mutual dependence accounted for by GM.	1	16.5	.652	.000
6.	Mutual dependence accounted for by PM.	2	3.1	.123	.207
7.	Total mutual dependence in GP, A.	5	81.8	--	.000
8.	Mutual dependence accounted for by GA.	1	53.5	.654	.000
9.	Mutual dependence accounted for by PA.	2	27.6	.337	.000
10.	Total mutual dependence in GPEAM, Y.	71	172.9	--	.000
11.	Mutual dependence accounted for by GY.	1	7.8	.045	.005
12.	Mutual dependence accounted for by PY.	2	4.4	.025	.109
13.	Mutual dependence accounted for by EY.	2	59.1	.342	.000
14.	Mutual dependence accounted for by AY.	1	11.7	.068	.001
15	Mutual dependence accounted for by SY.	1	.1	.001	.818
16.	MD accounted for by all 5 main effects.	7	83.5	.483	.020

Legend:
d.f. degrees of freedom
LRX^2 Likelihood-Ratio Chi-Square
CMPD Coefficient of Multiple-Partial Determination

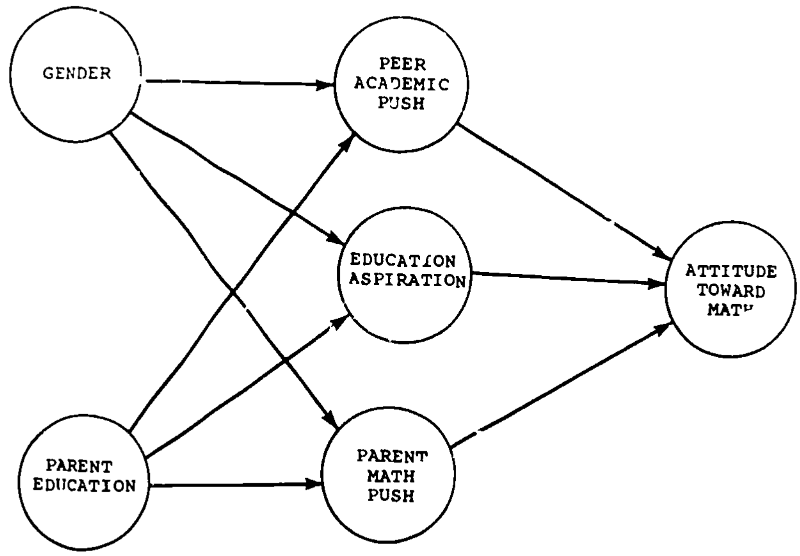

Figure 3: A Path Model to Predict Attitude toward Mathematics among 7th-Grade Students.

Table 4: Some Logit Models to Estimate the Strength of Selected Paths.

Model	Terms	d.f.	LRX^2	CMPD	P
1.	Total mutual dependence in GP, A.	5	81.8	--	.000
2.	Mutual dependence accounted for by GA.	1	53.5	.654	.000
3.	Mutual dependence accounted for by PA.	2	27.6	.337	.000
4.	Total mutual dependence in GP, E.	10	198.8	--	.000
5.	Mutual dependence accounted for by GE.	2	22.3	.112	.000
6.	Mutual dependence accounted for by PE.	4	176.9	.890	.000
7.	Total mutual dependence in GP, M.	5	56.1	--	.000
8.	Mutual dependence accounted for by GM.	1	8.5	.152	.004
9.	Mutual dependence accounted for by PM.	2	47.3	.843	.000
10.	Total mutual dependence in GPEAM, Y.	71	209.8	--	.000
11.	Mutual dependence accounted for by GY.	1	5.4	.026	.020
12.	Mutual dependence accounted for by PY.	2	5.7	.027	.058
13.	Mutual dependence accounted for by EY.	2	52.0	.248	.000
14.	Mutual dependence accounted for by AY.	1	6.6	.031	.010
15.	Mutual dependence accounted for by SY.	1	26.1	.124	.000
16.	MD accounted for by all 5 main effects.	7	109.7	.523	.003

Legend:
d.f. — degrees of freedom
LRX^2 — Likelihood-Ratio Chi-Square
CMPD — Coefficient of Multiple-Partial Determination

Turning to attitude toward science, a similar set of models were constructed and analyzed. The parent and peer push variables were changed from mathematics push to science push, but all other aspects of the models remained the same.

The first model included the parent academic push and the parent science push measures as well as gender and parent's education. The results indicated that all of the variables except parental education had a direct relationship with attitude toward science (see Figure 4). A set of logit analyses indicated that student's educational expectations was the strongest predictor, accounting for 27 per cent of the total mutual dependence in the model. Parent science push accounted for an additional 17 per cent of the mutual dependence and gender explained about eight per cent. As with math, the LSAY data found that 7th-grade girls were more likely to report parental science encouragement than were 7th-grade boys.

Looking at peer influences, a second model found that only student educational plans, peer academic encouragement, and gender had direct paths to attitude toward science (see Figure 5). In this model, student's educational aspirations accounted for 43 per cent of the total mutual dependence and gender explained an additional 14 per cent. As with math attitude, students who plan for college and graduate degrees are more likely to hold positive attitudes toward science than other students.

Given the results of these first two models, it is not necessary to construct a third model. It is clear from these results that student's educational aspiration is the dominant predictor of attitude toward science and that both parent science push and peer academic push enhance the likelihood that a 7th-grade student will hold positive views of science.

Some Conclusions

What can we conclude from these models? Two important points emerge that deserve additional discussion.

First, the role of parental education as the indirect fount of student attitudes toward science and mathematics emerges clearly. The strongest predictor of a student's educational expectations is the education of his or her parents. While the relationship is not perfect (and we should hope it never becomes so), it is strong and points to significant class and economic stratification. The level of educational expectation, in turn, is the strongest predictor of student attitudes toward science and mathematics. Further, parental education is also a strong predictor of both parent science and math push and peer academic push. The first relationship is obvious, and the second reflects the tendency of better educated parents to live in communities or school systems with better schools, thus enhancing the odds of peers who also appreciate education and hold higher educational aspirations.

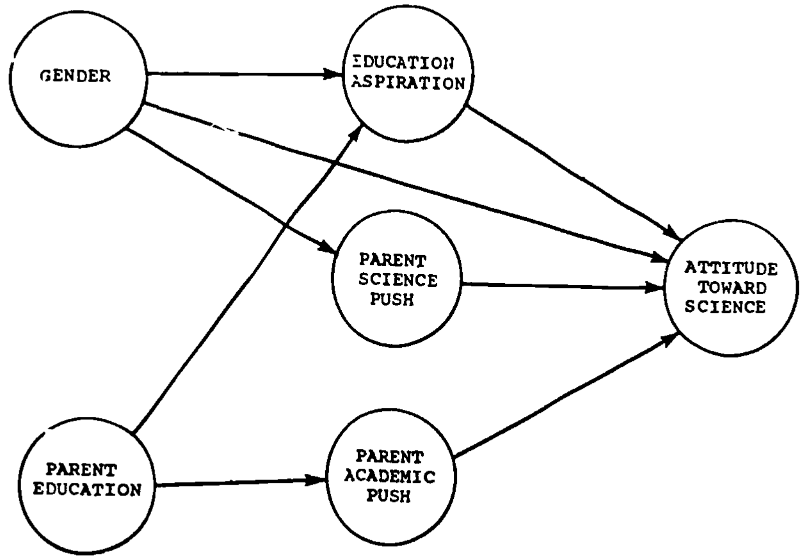

Figure 4: A Path Model to Predict Attitude toward Science among 7th-Grade Students.

Table 5: Some Logit Models to Estimate the Strength of Selected Paths.

Model	Terms	d.f.	LRX2	CMPD	P
1.	Total mutual dependence in GP, E.	10	198.8	--	.000
2.	Mutual dependence accounted for by GE.	2	22.3	.112	.000
3.	Mutual dependence accounted for by PE.	4	176.9	.890	.000
4.	Total mutual dependence in GP, S.	5	34.5	--	.000
5.	Mutual dependence accounted for by GS.	1	6.5	.188	.011
6.	Mutual dependence accounted for by PS.	2	24.5	.710	.000
7.	Total mutual dependence in GP, A.	5	39.9	--	.000
8.	Mutual dependence accounted for by GA.	1	.3	.008	.554
9.	Mutual dependence accounted for by PA.	2	34.6	.867	.000
10.	Total mutual dependence in GPEAS, Y.	71	325.4	--	.000
11.	Mutual dependence accounted for by GY.	1	25.5	.078	.000
12.	Mutual dependence accounted for by PY.	2	2.3	.007	.310
13.	Mutual dependence accounted for by EY.	2	88.3	.271	.000
14.	Mutual dependence accounted for by AY.	1	13.2	.041	.000
15.	Mutual dependence accounted for by SY.	1	55.3	.170	.000
16.	MD accounted for by all 5 main effects.	7	235.1	.722	.017

Legend:
- d.f. — degrees of freedom
- LRX^2 — Likelihood-Ratio Chi-Square
- CMPD — Coefficient of Multiple-Partial Determination

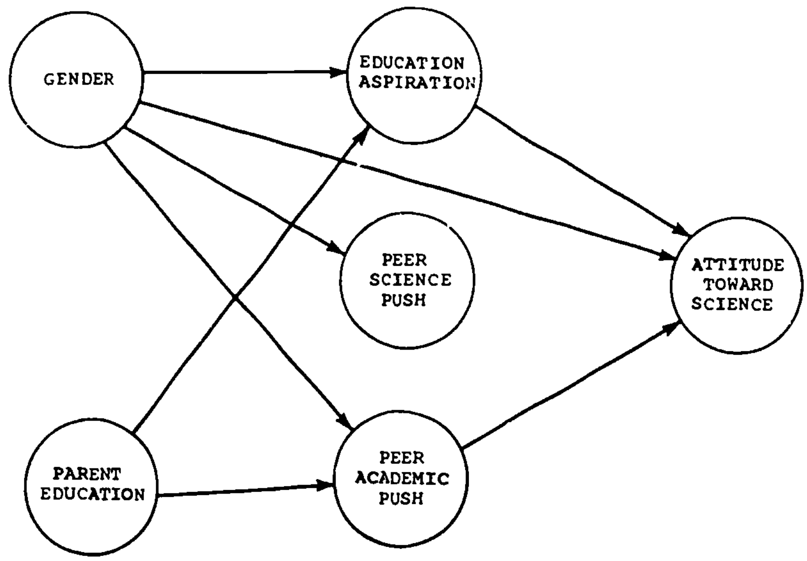

Figure 5: A Path Model to Predict Attitude toward Science among 7th-Grade Students.

Table 6: Some Logit Models to Estimate the Strength of Selected Paths.

Model	Terms	d.f.	LRX^2	CMPD	P
1.	Total mutual dependence in GP, E.	10	198.8	--	.000
2.	Mutual dependence accounted for by GE.	2	22.3	.112	.000
3.	Mutual dependence accounted for by PE.	4	16.9	.890	.000
4.	Total mutual dependence in GP, S.	5	33.9	--	.000
5.	Mutual dependence accounted for by GS.	1	18.5	.546	.000
6.	Mutual dependence accounted for by PS.	2	5.6	.165	.060
7.	Total mutual dependence in GP, A.	5	81.8	--	.000
8.	Mutual dependence accounted for by GA.	1	53.5	.654	.000
9.	Mutual dependence accounted for by PA.	2	27.6	.3[illegible]7	.000
10.	Total mutual dependence in GPEAS, Y.	71	253.5	--	.000
11.	Mutual dependence accounted for by GY.	1	34.4	.136	.000
12.	Mutual dependence accounted for by PY.	2	1.2	.005	.540
13.	Mutual dependence accounted for by EY.	2	110.0	.434	.000
14.	Mutual dependence accounted for by AY.	1	8.9	.035	.003
15.	Mutual dependence accounted for by SY.	1	3.2	.013	.072
16.	MD accounted for by all 5 main effects.	7	166.2	.656	.028

Legend:
- d.f. — degrees of freedom
- LRX^2 — Likelihood-Ratio Chi-Square
- CMPD — Coefficient of Multiple-Partial Determination

Second, the strong structural relationships found in this study of 7th-grade students points to the early development of general attitudes and the critical nature of the middle school years. While these analyses were cross-sectional in nature, we look forward to our longitudinal data to determine how much fluctuation there is in these attitudes and under what conditions both educational aspirations and attitudes can be changed. We look forward to sharing those results with you in future years.