DOCUMENT RESUME

ED 302 396 SE 050 230

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TITLE Parental and Peer Encouragement of Formal and Informal Science Education.
SPONS AGENCY National Science Foundation, Washington, D.C.
PUB DATE 6 Apr 88
GRANT MDR-8550085
NOTE 26p.; Paper presented at the Annual Meeting of the American Educational Research Association (New Orleans, LA, April 5-9, 1988). For related paper, see SE 050 229.
PUB TYPE Reports - Research/Technical (143) -- Speeches/Conference Papers (150)

EDRS PRICE MF01/PC02 Plus Postage.
DESCRIPTORS *Course Selection (Students); *Enrollment Influences; *Family Influence; Grade 7; Grade 10; Longitudinal Studies; Middle Schools; Models; *Peer Influence; Science Education; Secondary Education; *Secondary School Science; Statistical Analysis
IDENTIFIERS *Longitudinal Study of American Youth

ABSTRACT

The context of socialization in the second half of the 20th century is far different than any previous socialization environment. Children in the United States and in other industrialized countries grow to adulthood in an age of 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. The Longitudinal Study of American Youth (LSAY) is one effort to better understand the process of socialization. The LSAY will follow parallel national samples of seventh and tenth graders for four years, collecting data from the students and their parents, teachers, and school staffs. The base year for collection was 1987. This paper uses the preliminary results from the LSAY base year data set to examine attitudes toward science courses and student participation in informal science education, using a set of multivariate log-linear models to examine the structure of parental and peer influences on these attitudes. Several path models are advanced and evaluated to help explain the relationship between variables. (CW)

Parental and Peer Encouragement of

Formal and Informal Science Education

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

April 6, 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 data sets to examine student attitudes toward science courses and student participation in informal science education, using a set of multivariate log-linear models to examine the structure of parental and peer influences on these 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.

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[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

## Attitude toward Formal Science Education

The development of attitudes toward formal science courses is one of the foci of the LSAY. In most American high schools, enrollment in advanced science courses -- especially chemistry and physics -- has become elective and the majority of high school students are electing to avoid these courses. The parallel cohort design of the LSAY allows us to look at the attitudes of our 7th-grade cohort toward science courses during a time when virtually all students are required to take a science course and to contrast those attitudes with the views of 10th-grade students who are enrolled in high school science courses that they have selected, generally.

The measurement of student attitude toward science courses is direct. Each student in both cohorts was asked to complete a course grid, listing each course that he or she was taking in the Fall of 1987 and evaluating several dimensions of each course. The evaluations were collected using grade-card letter grades -- which student enjoy giving. This analysis will focus on only the first evaluative dimension, a question asking how much the student liked "the subject matter" of each course. Students were instructed to give the course an "A" if they "really like the subject" and we will dichotomize between A's and all other grades for the purpose of this analysis[3].

The results indicated that 42 per cent of 7th-grade students "really like" the substance of their science course (see Table 1). Interestingly, there are no significant differences by gender and only weak associations with the student's educational aspirations and his or her parent's education. In contrast, among high school sophomores, there is a small (but statistically significant) gender difference, with a higher proportion of young women reporting that they like their science course than young men. The association between student's educational aspiration and attitude toward science course remained weak among 10th-grade students, and the relationship between parental education and course attitude dissolved.

In the model building reported in the next section of this paper, four 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.

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[3]Other dimensions asked about the clarity of teaching, the clarity of the textbook, the difficulty of the course, the utility of the course for the student's career, the use of computers in the course, and the number of hours of homework each week.

Table 1: Student Attitude toward Science Courses.

| | 7th Grade | | | 10th Grade | | |
|---|---|---|---|---|---|---|
| | A | B-F | N | A | B-F | N |
| All Students | 42% | 58% | 2383 | 31% | 69% | 1719 |
| **Gender** | | | | | | |
| Male | 42 | 58 | 1097 | 29 | 71 | 858 |
| Female | 44 | 56 | 1193 | 33 | 67 | 806 |
| **Student Educational Aspiration** | | | | | | |
| Less than baccalaureate | 39 | 61 | 709 | 27 | 73 | 661 |
| Baccalaureate | 38 | 62 | 703 | 28 | 72 | 502 |
| Graduate degree | 50 | 50 | 722 | 42 | 59 | 453 |
| **Parents Education** | | | | | | |
| High school or less | 42 | 58 | 717 | 29 | 71 | 583 |
| Some college | 41 | 59 | 435 | 33 | 67 | 455 |
| Baccalaureate | 45 | 55 | 613 | 31 | 69 | 511 |
| **Parent Academic Push** | | | | | | |
| Low | 40 | 60 | 1246 | 28 | 72 | 1219 |
| High | 45 | 55 | 1137 | 38 | 62 | 500 |
| **Parent Science Push** | | | | | | |
| Low | 39 | 61 | 1928 | 26 | 74 | 1081 |
| High | 56 | 44 | 455 | 39 | 61 | 638 |
| **Peer Academic Push** | | | | | | |
| Low | 39 | 61 | 1129 | 26 | 74 | 961 |
| High | 45 | 55 | 1254 | 37 | 63 | 759 |
| **Peer Science Push** | | | | | | |
| Low | 40 | 60 | 1938 | 27 | 73 | 1250 |
| High | 50 | 50 | 445 | 43 | 57 | 469 |

"How much do you like the subject matter of each course? A means you really like the subject; F means you hate it."

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 attitude toward science course 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 attitude toward science course in the LSAY data.

Peer Academic Push refers to peer encouragement of school and learning generally. It was designed to parallel parental academic encouragement, but obviously the items must be different to reflect the peer context. 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 attitude toward science course 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.

In summary, the student's attitude toward his or her science course appears to be positively associated with all of the demographic and encouragement variables just noted. To better understand the combinations of demographic and other influences that foster positive student attitudes toward science courses, we will now turn to the task of constructing some models of this attitude.

## Some Models to Predict Student Attitude toward Science Courses

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 courses 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 our 7th grade cohort, 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, and the level of parent academic push. These are four 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. Both the level of student educational aspiration and parent academic push are positively associated with the student's attitude toward science courses. The absence of a direct path from either gender or parental education to course attitude indicates that the influence of these two variables is fully accounted for in the levels of student educational aspiration and in parent academic push and that there is no residual direct influence on course 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.

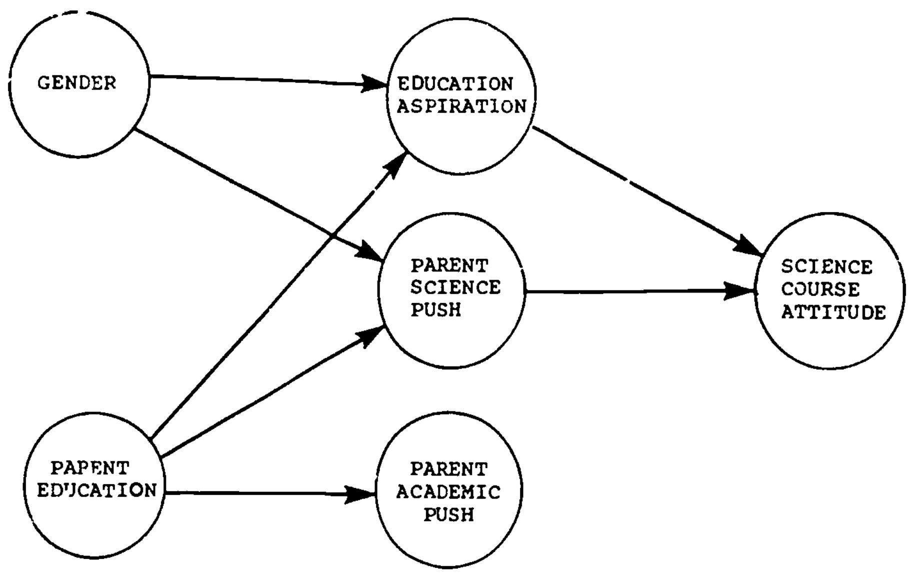


Figure 1: A Path Model to Predict Attitude toward Science Course, among 7th-Grade Students.

Table 2: 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, A. | 5 | 39.9 | -- | .000 |
| 5. | Mutual dependence accounted for by GA. | 1 | .3 | .008 | .554 |
| 6. | Mutual dependence accounted for by PA. | 2 | 34.6 | .867 | .000 |
| 7. | Total mutual dependence in GP, S. | 5 | 34.5 | -- | .000 |
| 8. | Mutual dependence accounted for by GS. | 1 | 6.5 | .188 | .011 |
| 9. | Mutual dependence accounted for by PS. | 2 | 24.5 | .710 | .000 |
| 10. | Total mutual dependence in GPEAS, Y. | 71 | 142.2 | -- | .000 |
| 11. | Mutual dependence accounted for by GY. | 1 | 5.9 | .041 | .015 |
| 12. | Mutual dependence accounted for by PY. | 2 | .5 | .004 | .793 |
| 13. | Mutual dependence accounted for by EY. | 2 | 21.3 | .150 | .000 |
| 14. | Mutual dependence accounted for by AY. | 1 | .1 | .001 | .720 |
| 15. | Mutual dependence accounted for by SY. | 1 | 20.1 | .141 | .000 |
| 16. | MD accounted for by all 5 main effects. | 7 | 56.5 | .397 | .037 |

Legend:
d.f. degrees of freedom
LRX² Likelihood-Ratio Chi-Square
CMPD Coefficient of Multiple-Partial Determination

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[4] 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 academic push. The results indicate that parental education is positively and strongly associated with the level of parent academic push. There is no significant relationship between gender and the level of parent academic push, suggesting that parents push their sons and daughters toward general academic achievement without regard to gender.

Models 7, 8, and 9 estimate the paths from gender and parental education to parental science push. The results indicate that both parental education and gender are associated with parent science push at the .01 level, but that the influence of parental education is far greater than the influence of gender. It should be noted that the LSAY data indicate that a higher proportion of 7th-grade girls reported parental science encouragement than did 7th-grade boys.

Models 10 through 16 describe the relationships between each of the independent variables and attitude toward science courses. The results indicate that student's educational aspiration and parent science push are the strongest predictors of positive attitudes toward science courses, with each accounting for slightly more than 20 per cent of the total mutual dependence in the model. In contrast, parent academic push accounted for less than one per cent of the total mutual dependence. This result suggests that while general parental academic encouragement may foster positive attitudes toward schooling, it is specific parental encouragement of science and of higher levels of educational achievement that fosters positive attitudes toward formal science courses.

Turning to the issue of the influence of peers on attitude toward science courses, the path analysis indicated that both parental education and gender were associated with peer academic push and peer science push (see Figure 2). 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 science

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[4]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.

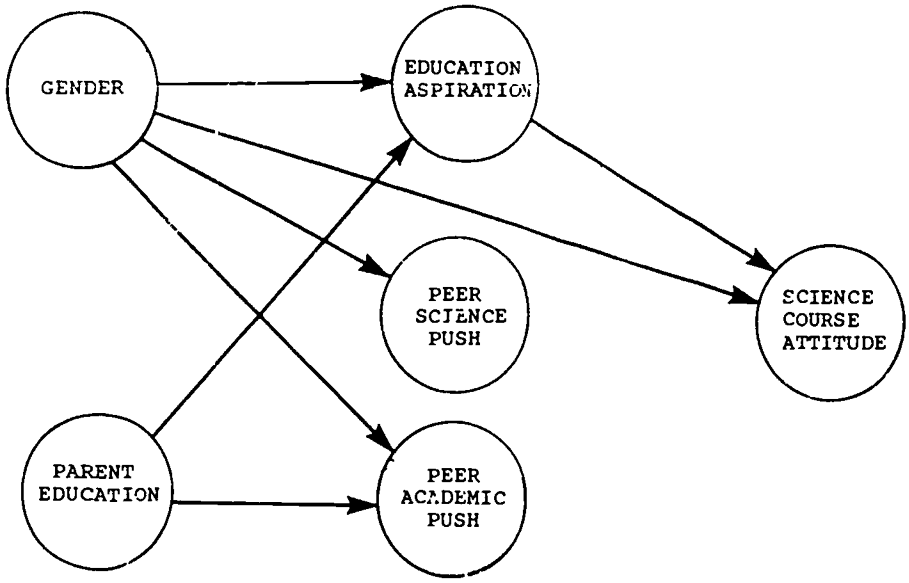


Figure 2: A Path Model to Predict Attitude toward Science Course, among 7th-Grade Students.

Table 3: 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, A. | 5 | 81.8 | -- | .000 |
| 5. | Mutual dependence accounted for by GA. | 1 | 53.5 | .654 | .000 |
| 6. | Mutual dependence accounted for by PA. | 2 | 27.6 | .337 | .000 |
| 7. | Total mutual dependence in GP, S. | 5 | 33.9 | -- | .000 |
| 8. | Mutual dependence accounted for by GS. | 1 | 18.5 | .546 | .000 |
| 9. | Mutual dependence accounted for by PS. | 2 | 5.6 | .165 | .060 |
| 10. | Total mutual dependence in GPEAS, Y. | 71 | 121.5 | -- | .000 |
| 11. | Mutual dependence accounted for by GY. | 1 | 6.8 | .056 | .009 |
| 12. | Mutual dependence accounted for by PY. | 2 | .2 | .002 | .909 |
| 13. | Mutual dependence accounted for by EY. | 2 | 26.6 | .219 | .000 |
| 14. | Mutual dependence accounted for by AY. | 1 | 1.6 | .013 | .203 |
| 15. | Mutual dependence accounted for by SY. | 1 | 5.1 | .042 | .025 |
| 16. | MD accounted for by all 5 main effects. | 7 | 43.1 | .355 | .106 |

Legend: d.f. degrees of freedom
LRX² Likelihood-Ratio Chi-Square
CMPD Coefficient of Multiple-Partial Determination

encouragement than were 7th-grade boys. The association between parental education and peer academic encouragement and peer science encouragement reflects the tendency of better educated parents to live in school attendance districts in which a higher proportion of other parents and their youngsters value education. To a large extent, it is a reflection of general social class and of economic affluence. In any case, this result suggests that the 7th-grade students of better educated parents are significantly more likely to receive peer academic and science encouragement than the children of less well educated parents.

The path analysis indicated that, in this model, student's educational aspiration and gender had direct associations with attitudes toward science courses, holding constant the other independent variables (see Figure 2). An examination of the strength of each of the direct paths indicates that student's educational aspirations were the strongest predictor, accounting for about 22 per cent of the total mutual dependence in the model (see Table 3). In contrast, gender accounted for about seven per cent of the mutual dependence.

Given the results of the first two models, it is possible to construct a simplified model to predict student attitude toward science courses. This final 7th-grade model included gender, parent's education, student's educational aspiration, and parent science push. The path analysis indicated that both student's expected level of education and parent science push were the strongest direct predictors of a positive attitude toward science courses, accounting for slightly over 20 per cent of the total mutual dependence each (see Figure 3 and Table 4). Gender also had a direct relationship (significant at the .01 level) with course attitude, but explained only seven per cent of the mutual dependence in the model.

Turning to the 10th-grade cohort, a parallel set of analyses were conducted. The relative influence of gender, parent's education, student's educational aspiration, parent academic push, and parent science push was studied. The path analysis indicated that student's educational aspirations and parent science push were the only two significant predictors of attitude toward science courses, displaying a pattern similar to that found in the 7th grade cohort (see Figure 4 and Table 5). As with the 7th-grade cohort, parent academic push did not have a significant residual relationship with science course attitude when the other independent variables were held constant.

A path analysis of the influence of peer academic push and peer science push found that both student's educational aspiration and peer science push had a positive relationship with science course attitude (see Figure 5 and Table 6). The logit analyses indicated that peer science push accounted for approximately 20 per cent of the total mutual dependence in the model, while student's educational aspiration explained 16 per cent.

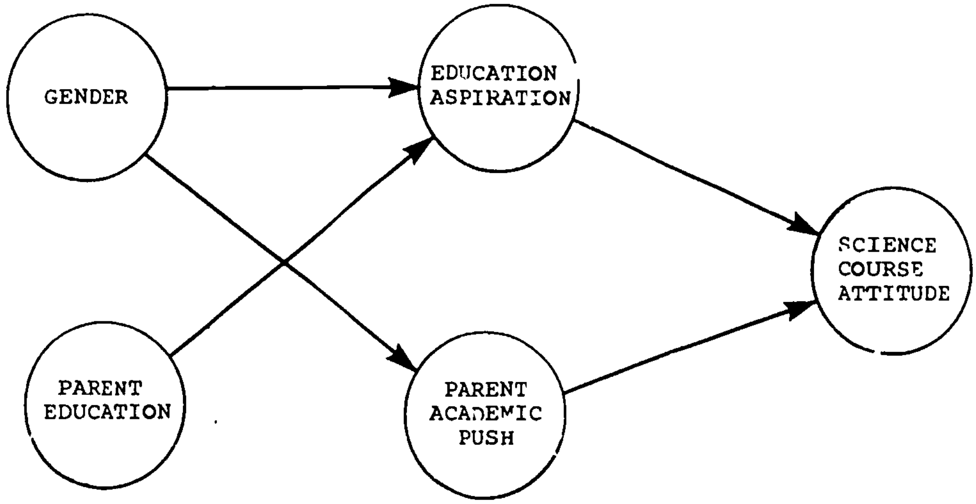


Figure 3: A Path Model to Predict Attitude toward Science Course, among 7th-Grade Students.

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, 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 GPES, Y. | 35 | 87.5 | -- | .000 |
| 8. | Mutual dependence accounted for by GY. | 1 | 6.0 | .069 | .014 |
| 9. | Mutual dependence accounted for by PY. | 2 | .4 | .005 | .806 |
| 10. | Mutual dependence accounted for by EY. | 2 | 21.5 | .246 | .000 |
| 11. | Mutual dependence accounted for by SY. | 1 | 22.0 | .251 | .000 |
| 12. | MD accounted for by all 4 main effects. | 6 | 56.3 | .643 | .357 |

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

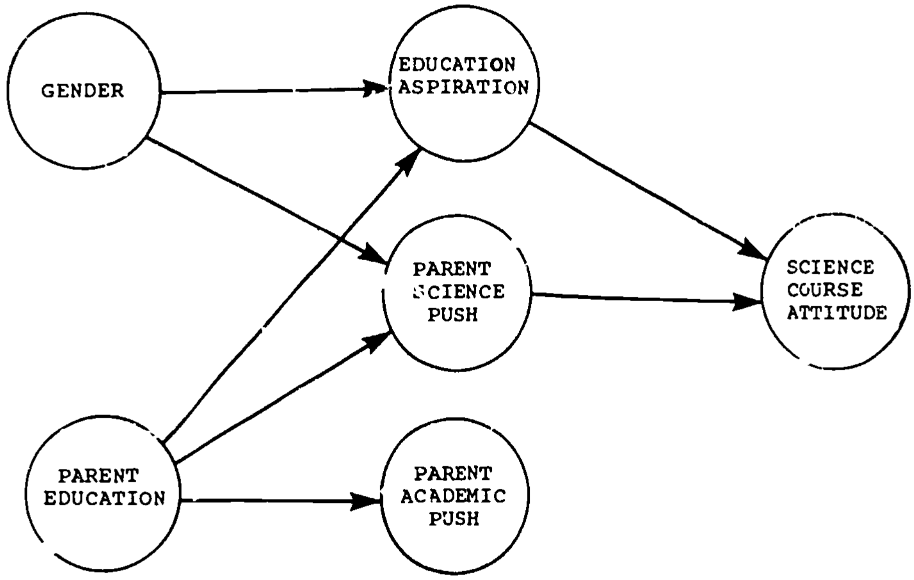


Figure 4: A Path Model to Predict Attitude toward Science Course, among 10th-Grade Students.

Table 5: 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 | 287.7 | -- | .000 |
| 2. | Mutual dependence accounted for by GE. | 2 | 15.3 | .055 | .000 |
| 3. | Mutual dependence accounted for by PE. | 4 | 261.3 | .938 | .000 |
| 4. | Total mutual dependence in GP, A. | 5 | 92.7 | -- | .000 |
| 5. | Mutual dependence accounted for by GA. | 1 | 2.4 | .026 | .119 |
| 6. | Mutual dependence accounted for by PA. | 2 | 89.0 | .960 | .000 |
| 7. | Total mutual dependence in GP, S. | 5 | 69.8 | -- | .000 |
| 8. | Mutual dependence accounted for by GS. | 1 | 9.7 | .139 | .002 |
| 9. | Mutual dependence accounted for by PS. | 2 | 49.1 | .703 | .000 |
| 10. | Total mutual dependence in GPEAS, Y. | 71 | 178.7 | -- | .000 |
| 11. | Mutual dependence accounted for by GY. | 1 | 2.0 | .011 | .153 |
| 12. | Mutual dependence accounted for by PY. | 2 | 5.8 | .032 | .055 |
| 13. | Mutual dependence accounted for by EY. | 2 | 18.7 | .105 | .000 |
| 14. | Mutual dependence accounted for by AY. | 1 | 6.0 | .034 | .015 |
| 15. | Mutual dependence accounted for by SY. | 1 | 17.0 | .095 | .000 |
| 16. | MD accounted for by all 5 main effects. | 7 | 60.2 | .339 | .000 |

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

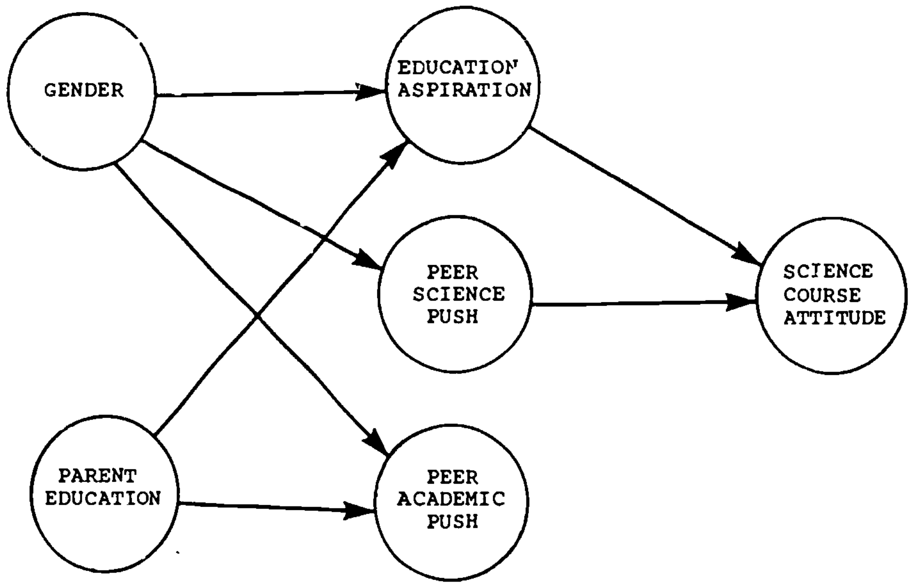


**Figure 5:** A Path Model to Predict Attitude toward Science Course, among 10th-Grade Students.

Table 6: 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 | 287.7 | -- | .000 |
| 2. | Mutual dependence accounted for by GE. | 2 | 15.3 | .055 | .000 |
| 3. | Mutual dependence accounted for by PE. | 4 | 261.3 | .938 | .000 |
| 4. | Total mutual dependence in GP, A. | 5 | 67.9 | -- | .000 |
| 5. | Mutual dependence accounted for by GA. | 1 | 49.6 | .730 | .000 |
| 6. | Mutual dependence accounted for by PA. | 2 | 20.4 | .300 | .000 |
| 7. | Total mutual dependence in GP, S. | 5 | 11.0 | -- | .051 |
| 8. | Mutual dependence accounted for by GS. | 1 | 6.6 | .600 | .0[illegible]0 |
| 9. | Mutual dependence accounted for by PS. | 2 | 3.3 | .300 | .195 |
| 10. | Total mutual dependence in GPEAS, Y. | 71 | 165.1 | -- | .000 |
| 11. | Mutual dependence accounted for by GY. | 1 | 2.8 | .017 | .094 |
| 12. | Mutual dependence accounted for by PY. | 2 | 1.7 | .010 | .418 |
| 13. | Mutual dependence accounted for by EY. | 2 | 16.0 | .097 | .000 |
| 14. | Mutual dependence accounted for by AY. | 1 | 1.4 | .008 | .242 |
| 15. | Mutual dependence accounted for by SY. | 1 | 20.3 | .123 | .000 |
| 16. | MD accounted for by all 5 main effects. | 7 | 61.8 | .374 | .001 |

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

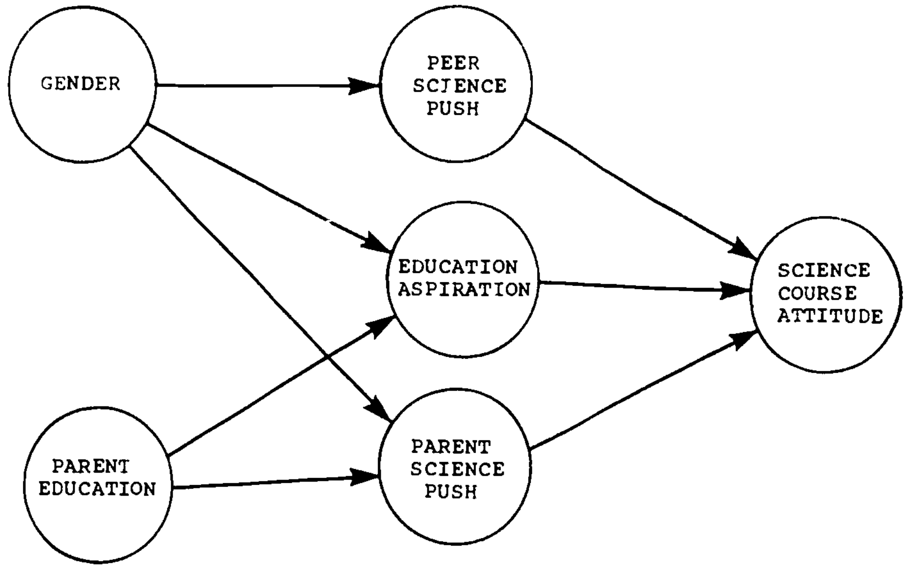


Figure 6: A Path Model to Predict Attitude toward Science Course, among 10th-Grade Students.

Table 7: Some Logit Models to Estimate the Strength of Selected Paths.

| Model | Terms | d.f. | LRX2 | CMPD | P |
|---|---|---|---|---|---|
| 1. | Total mutual dependence in GP, F. | 5 | 11.0 | -- | .051 |
| 2. | Mutual dependence accounted for by GF. | 1 | 6.6 | .600 | .010 |
| 3. | Mutual dependence accounted for by PF. | 2 | 3.3 | .300 | .195 |
| 4. | Total mutual dependence in GP, E. | 10 | 287.7 | -- | .000 |
| 5. | Mutual dependence accounted for by GE. | 2 | 15.3 | .055 | .000 |
| 6. | Mutual dependence accounted for by PE. | 4 | 261.3 | .938 | .000 |
| 7. | Total mutual dependence in GP, S. | 5 | 69.8 | -- | .000 |
| 8. | Mutual dependence accounted for by GS. | 1 | 9.7 | .139 | .002 |
| 9. | Mutual dependence accounted for by PS. | 2 | 49.1 | .703 | .000 |
| 10. | Total mutual dependence in GPESF, Y. | 71 | 163.3 | -- | .000 |
| 11. | Mutual dependence accounted for by GY. | 1 | 1.2 | .007 | .281 |
| 12. | Mutual dependence accounted for by PY. | 2 | 2.9 | .018 | .236 |
| 13. | Mutual dependence accounted for by EY. | 2 | 13.8 | .085 | .001 |
| 14. | Mutual dependence accounted for by SY. | 1 | 14.1 | .086 | .000 |
| 15. | Mutual dependence accounted for by FY. | 1 | 20.2 | .124 | .000 |
| 16. | MD accounted for by all 5 main effects. | 7 | 74.5 | .456 | .022 |

Legend:
- d.f. — degrees of freedom
- LRX2 — Likelihood-Ratio Chi-Square
- CMPD — Coefficient of Multiple-Partial Determination

For our 10th-grade cohort, a final model must include gender, parent's education, parent science push, peer science push, and student's educational aspiration. This path analysis indicates student's educational aspiration, parent science push, and peer science push all have significant residual relationships with science course attitude, when gender and parental education are held constant (see Figure 6 and Table 7). In this model, peer science encouragement was the strongest predictor of a positive attitude toward science courses, accounting for 20 per cent of the total mutual dependence. Both parent science encouragement and student's educational aspiration accounted for about 14 per cent of the mutual dependence each.

Looking at this set of models, it appears that science course attitudes are influenced by educational aspirations and peer science encouragement in both cohorts, with peer encouragement becoming slightly more important among high school students. It is important to note that young women report more positive attitudes toward science courses and more peer science encouragement than young men. This result runs counter to conventional wisdom in this area, but other analyses of the LSAY data have found that a higher proportion of young men plan for a career in science and engineering than young women, pointing to both the irony and the strength of other social forces in shaping career preferences.

## Participation in Informal Science Education

The preceding analysis focused on student's attitude toward formal science courses in a school setting. Informal science education provides another source of science information and learning, and national data suggests that American utilization of informal science education activities like science museums and science television has been increasing in recent decades. The LSAY collected a number of items concerning student participation in informal science education and this section of the analysis will examine the rate of participation, using a similar set of parental and peer predictor variables. The comparison with formal science course work should be both interesting and helpful.

For this analysis, participation in informal science education is measured by the number of student agreements to the following statements:

I have visited a science museum.
I have talked to a scientist or engineer.
Last summer, I visited a science museum, natural history museum, or planetarium.
Last summer, I visited a zoo, aquarium, or botanical garden.
Last summer, I read a science fiction story.
This semester, I belong to a science, math, or computer club.

The list of possible activities is not a comprehensive battery of informal science education activities, but it covers a wide array of types of activities in which a young person might engage. For the models that follow, this index as dichotomized into those students that reported four or more activities and those that reported a lower number.

An examination of the distribution of both cohorts on this measure indicated that 38 per cent of 7th-grade students and 27 per cent of 10th-grade students had participated at a moderately high rate in informal science education (see Table 8). Young women were more likely to have participated in informal science education than young men. Both parent's education and student's educational plans were strongly and positively associated with participation in informal science education. Not surprisingly, all of the parental and peer encouragement variables were also strongly and positively associated with a high level of informal science education participation. To better understand the relative influence of each of these variables, a series of path and logit analyses were conducted, parallel in structure to those reported above attitudes toward formal science courses.

Looking first at the 7th-grade cohort, the first model examined the relative influence of gender, parent's education, student's educational aspiration, parent academic push, and parent science push. The path analysis found that all five of these variables had direct paths to participation in informal science education, and a logit analysis indicated that parent science encouragement was the strongest single predictor of a high level of informal science participation, accounting for 28 per cent of the total mutual dependence in the model (see Figure 7 and Table 9). This pattern suggests that student's educational aspiration, while still important, is significantly less important in predicting participation in informal science education than in predicting attitude toward formal science courses.

Looking at peer influences, a path analysis found gender, parent's education, student's educational aspiration, peer academic encouragement, and peer science push all to have direct residual relationships with a high level of participation in informal science education. A set of logit analyses indicated that peer science encouragement was the strongest single predictor of informal science participation, accounting for 34 per cent of the total mutual dependence in the model (see Figure 8 and Table 10). Again, student's educational aspiration had significantly reduced influence relative to peer science encouragement.

It is possible to construct a final 7th-grade model that incorporates the best predictors from the parental and peer models. This final 7th-grade model included gender, parent's education, student's educational plans, parent science push, and peer science push. The resulting path analysis found that all five variables had significant direct paths to informal science education participation, but that the strongest predictor was parent science encouragement, which accounted for 30 per cent of the total mutual dependence (see Figure 9 and Table 11). This may reflect parental control of family transportation and the emphasis in the measure on museums, but it points to real parameters that may influence the level of student participation in informal education. The second strongest predictor was peer science encouragement, which explained about 11 per cent of the mutual dependence.

Table 8: Student Participation in Informal Science Education.

| | 7th Grade | | | 10th Grade | | |
|---|---|---|---|---|---|---|
| | Low | High | N | Low | High | N |
| All Students | 62% | 38% | 2758 | 73% | 27% | 2054 |
| Gender | | | | | | |
| Male | 66 | 34 | 1282 | 75 | 25 | 1023 |
| Female | 58 | 42 | 1369 | 69 | 31 | 970 |
| Student Educational Aspiration | | | | | | |
| Less than baccalaureate | 68 | 32 | 824 | 82 | 18 | 919 |
| Baccalaureate | 65 | 35 | 801 | 74 | 26 | 531 |
| Graduate degree | 53 | 47 | 838 | 57 | 43 | 534 |
| Parents Education | | | | | | |
| High school or less | 67 | 33 | 795 | 80 | 20 | 709 |
| Some college | 63 | 37 | 518 | 74 | 26 | 531 |
| Baccalaureate | 50 | 50 | 728 | 60 | 40 | 611 |
| Parent Academic Push | | | | | | |
| Low | 70 | 30 | 1434 | 78 | 22 | 1453 |
| High | 53 | 47 | 1323 | 60 | 40 | 601 |
| Parent Science Push | | | | | | |
| Low | 67 | 33 | 2238 | 81 | 19 | 1338 |
| High | 39 | 61 | 520 | 57 | 43 | 716 |
| Peer Academic Push | | | | | | |
| Low | 69 | 31 | 1290 | 79 | 21 | 1166 |
| High | 56 | 44 | 1468 | 64 | 36 | 888 |
| Peer Science Push | | | | | | |
| Low | 66 | 34 | 2249 | 78 | 22 | 1480 |
| High | 43 | 57 | 509 | 59 | 41 | 574 |

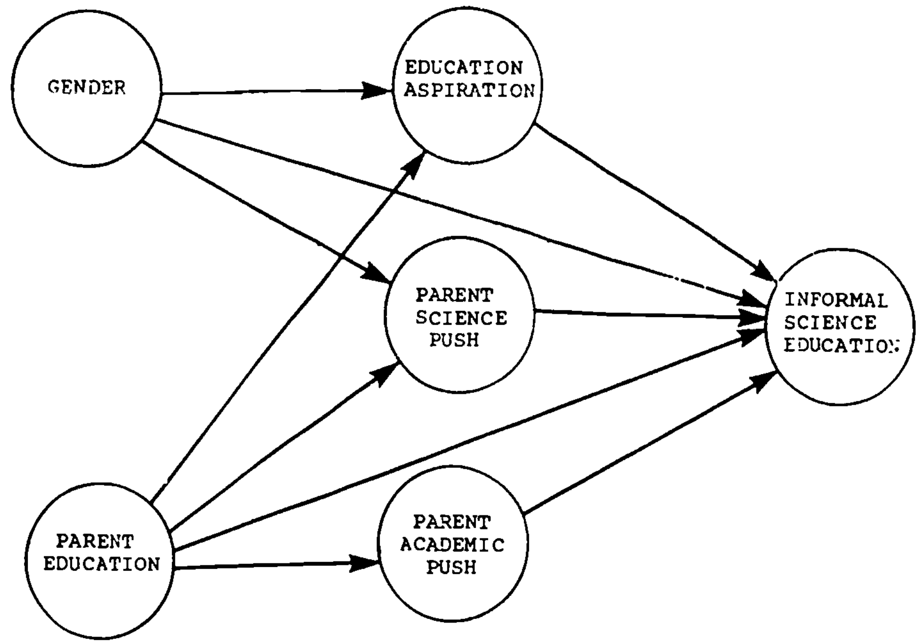


Figure 7: A Path Model to Predict Participation in Informal Science Education, among 7th-Grade Students.

Table 9: 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, A. | 5 | 39.9 | -- | .000 |
| 5. | Mutual dependence accounted for by GA. | 1 | .3 | .008 | .554 |
| 6. | Mutual dependence accounted for by PA. | 2 | 34.6 | .867 | .000 |
| 7. | Total mutual dependence in GP, S. | 5 | 34.5 | -- | .000 |
| 8. | Mutual dependence accounted for by GS. | 1 | 6.5 | .188 | .011 |
| 9. | Mutual dependence accounted for by PS. | 2 | 24.5 | .710 | .000 |
| 10. | Total mutual dependence in GPEAS, Y. | 71 | 245.3 | -- | .000 |
| 11. | Mutual dependence accounted for by GY. | 1 | 15.7 | .064 | .000 |
| 12. | Mutual dependence accounted for by PY. | 2 | 18.1 | .074 | .000 |
| 13. | Mutual dependence accounted for by EY. | 2 | 12.3 | .050 | .002 |
| 14. | Mutual dependence accounted for by AY. | 1 | 12.1 | .049 | .001 |
| 15. | Mutual dependence accounted for by SY. | 1 | 68.3 | .278 | .000 |
| 16. | MD accounted for by all 5 main effects. | 7 | 178.8 | .729 | .392 |

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

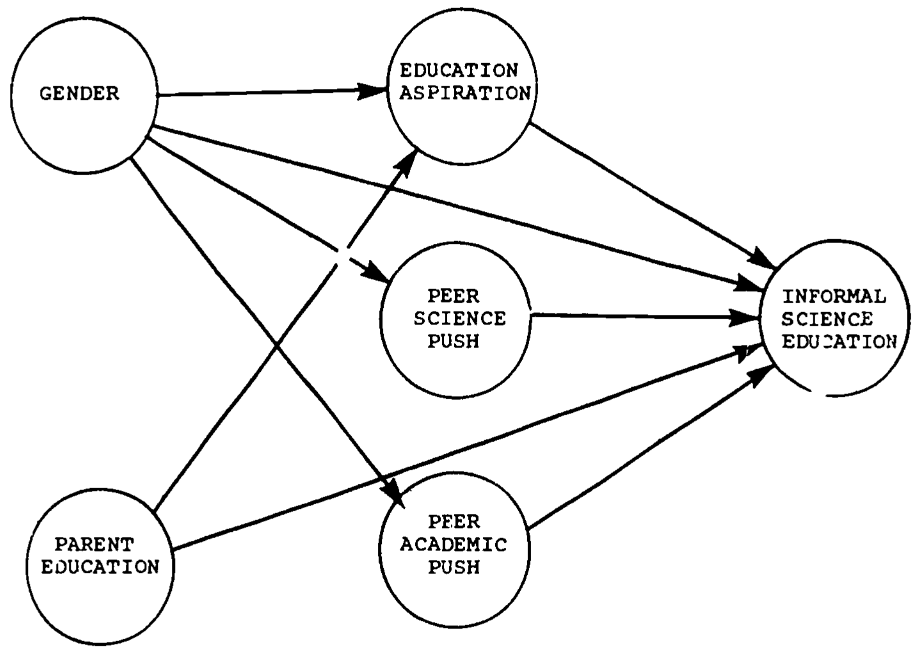


**Figure 8: A Path Model to Predict Participation in Informal Science Education, among 7th-Grade Students.**

Table 10: **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, A. | 5 | 81.8 | -- | .000 |
| 5. | Mutual dependence accounted for by GA. | 1 | 53.5 | .654 | .000 |
| 6. | Mutual dependence accounted for by PA. | 2 | 27.6 | .337 | .000 |
| 7. | Total mutual dependence in GP, S. | 5 | 33.9 | -- | .000 |
| 8. | Mutual dependence accounted for by GS. | 1 | 18.5 | .546 | .000 |
| 9. | Mutual dependence accounted for by PS. | 2 | 5.6 | .165 | .060 |
| 10. | Total mutual dependence in GPEAS, Y. | 71 | 249.6 | -- | .000 |
| 11. | Mutual dependence accounted for by GY. | 1 | 21.8 | .087 | .000 |
| 12. | Mutual dependence accounted for by PY. | 2 | 19.1 | .077 | .000 |
| 13. | Mutual dependence accounted for by EY. | 2 | 19.1 | .077 | .000 |
| 14. | Mutual dependence accounted for by AY. | 1 | 16.6 | .067 | .000 |
| 15. | Mutual dependence accounted for by SY. | 1 | 33.7 | .135 | .000 |
| 16. | MD accounted for by all 5 main effects. | 7 | 33.7 | .135 | .000 |

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

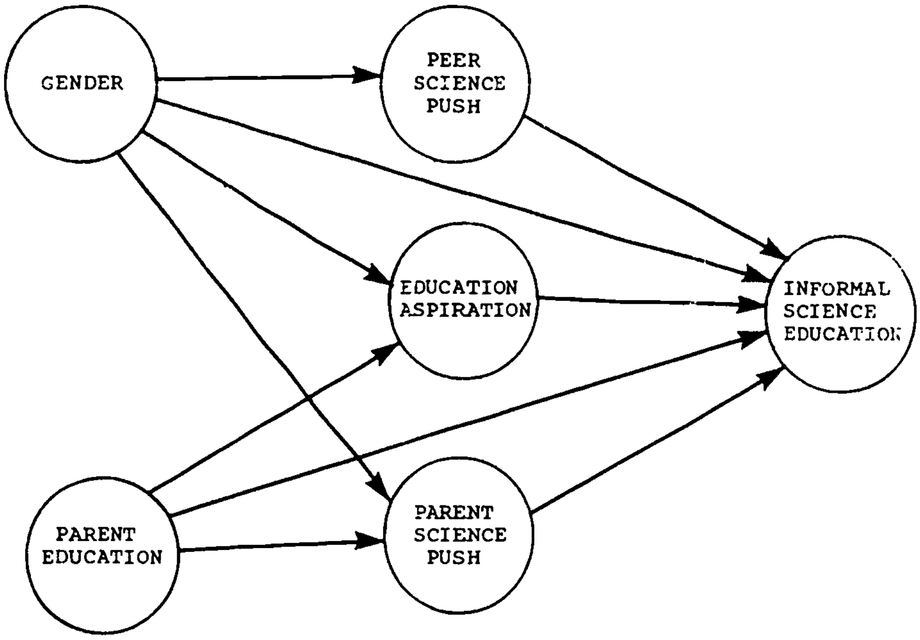


Figure 9: A Path Model to Predict Participation in Informal Science Education, among 7th-Grade Students.

Table 11: Some Logit Models to Estimate the Strength of Selected Paths.

| Model | Terms | d.f. | $LRX^2$ | CMPD | P |
|---|---|---|---|---|---|
| 1. | Total mutual dependence in GP, F. | 5 | 33.9 | -- | .000 |
| 2. | Mutual dependence accounted for by GF. | 1 | 18.5 | .546 | .000 |
| 3. | Mutual dependence accounted for by PF. | 2 | 5.6 | .165 | .060 |
| 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, S. | 5 | 34.5 | -- | .000 |
| 8. | Mutual dependence accounted for by GS. | 1 | 6.5 | .188 | .011 |
| 9. | Mutual dependence accounted for by PS. | 2 | 24.5 | .710 | .000 |
| 10. | Total mutual dependence in GPESF, Y. | 71 | 280.3 | -- | .000 |
| 11. | Mutual dependence accounted for by GY. | 1 | 13.3 | .047 | .000 |
| 12. | Mutual dependence accounted for by PY. | 2 | 18.0 | .064 | .000 |
| 13. | Mutual dependence accounted for by EY. | 2 | 13.1 | .047 | .002 |
| 14. | Mutual dependence accounted for by SY. | 1 | 66.1 | .236 | .000 |
| 15. | Mutual dependence accounted for by FY. | 1 | 30.4 | .108 | .000 |
| 16. | MD accounted for by all 5 main effects. | 7 | 197.1 | .703 | .054 |

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

Turning to the 10th-grade cohort, a similar set of models was constructed to understand parent and peer influences. The independent variables reflect the same measures used in the earlier analysis of 10th-grade student attitudes toward science courses.

The first model examined the influence of parent academic push and parent science push within the context of student gender and parent's education. The path analysis found that all five variables had direct paths to the level of informal science education participation, but that parent science encouragement was by far the strongest single predictor of a high level of participation (see Figure 10 and Table 12). Parent science push accounted for 16 per cent of the total mutual dependence in the model. Student's educational aspirations was the second strongest predictor, accounting for about 11 per cent.

A second model examined the influence of peer academic encouragement and peer science encouragement and found that all five of the variables had direct paths to the level of participation in informal science education. In this model, however, the strongest single predictor was the student's level of educational aspiration (see Figure 11 and Table 13). There was a relatively strong residual influence from the level of parent's education.

A final 10th-grade model was developed, taking into account the results of the first t' ) models. This final model parallels the 7th-grade model, including gender, parent's education, student's expected education, parent science push, and peer science push. The resulting path analysis found that parent science encouragement was the strongest predictor of the level of informal science education participation (see Figure 12 and Table 14). This result is the same as that found for the 7th-grade cohort, providing some confirmation that these influences persist across the middle and high school years.

## Some Conclusions

This analysis utilized the base year results of the Longitudinal Study of American Youth to examine the developmental structure of student attitudes toward formal science courses in the school setting and the level of participation in informal science education. The results point to a structure rooted in the level of parental education, with some minor gender influences.

The level of parental education is strongly associated with the student's own educational aspirations, indicating that the children of college-educated parents are significantly more likely to plan to complete college than other students. This higher level of educational aspiration translates into a more positive attitude toward science courses in school, and is enhanced by a high level of parent science encouragement. In other analyses, we will explore in greater detail the channels and substance of parent science encouragement, but it is sufficient to note at this point that parent influence on attitude toward science is strong.

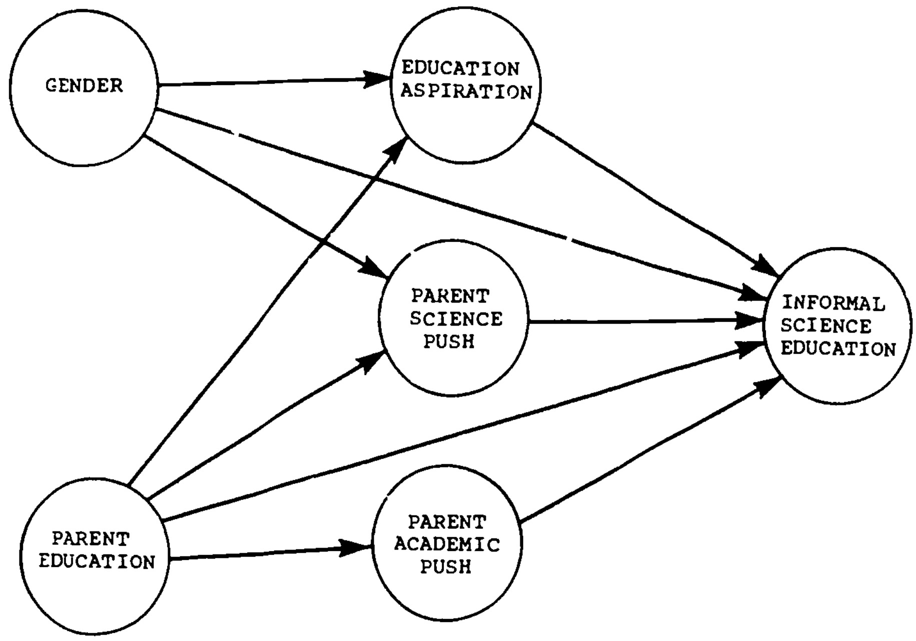


**Figure 10: A Path Model to Predict Participation in Informal Science Education, among 10th-Grade Students.**

Table 12: 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 | 287.7 | -- | .000 |
| 2. | Mutual dependence accounted for by GE. | 2 | 15.3 | .055 | .000 |
| 3. | Mutual dependence accounted for by PE. | 4 | 261.3 | .938 | .000 |
| 4. | Total mutual dependence in GP, A. | 5 | 92.7 | -- | .000 |
| 5. | Mutual dependence accounted for by GA. | 1 | 2.4 | .026 | .119 |
| 6. | Mutual dependence accounted for by PA. | 2 | 89.0 | .960 | .000 |
| 7. | Total mutual dependence in GP, S. | 5 | 69.8 | -- | .000 |
| 8. | Mutual dependence accounted for by GS. | 1 | 9.7 | .139 | .002 |
| 9. | Mutual dependence accounted for by PS. | 2 | 49.1 | .703 | .000 |
| 10. | Total mutual dependence in GPEAS, Y. | 71 | 385.1 | -- | .000 |
| 11. | Mutual dependence accounted for by GY. | 1 | 6.8 | .018 | .009 |
| 12. | Mutual dependence accounted for by PY. | 2 | 16.5 | .043 | .000 |
| 13. | Mutual dependence accounted for by EY. | 2 | 40.3 | .105 | .000 |
| 14. | Mutual dependence accounted for by AY. | 1 | 6.4 | .017 | .011 |
| 15. | Mutual dependence accounted for by SY. | 1 | 61.9 | .161 | .000 |
| 16. | MD accounted for by all 5 main effects. | 7 | 225.2 | .585 | .000 |

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

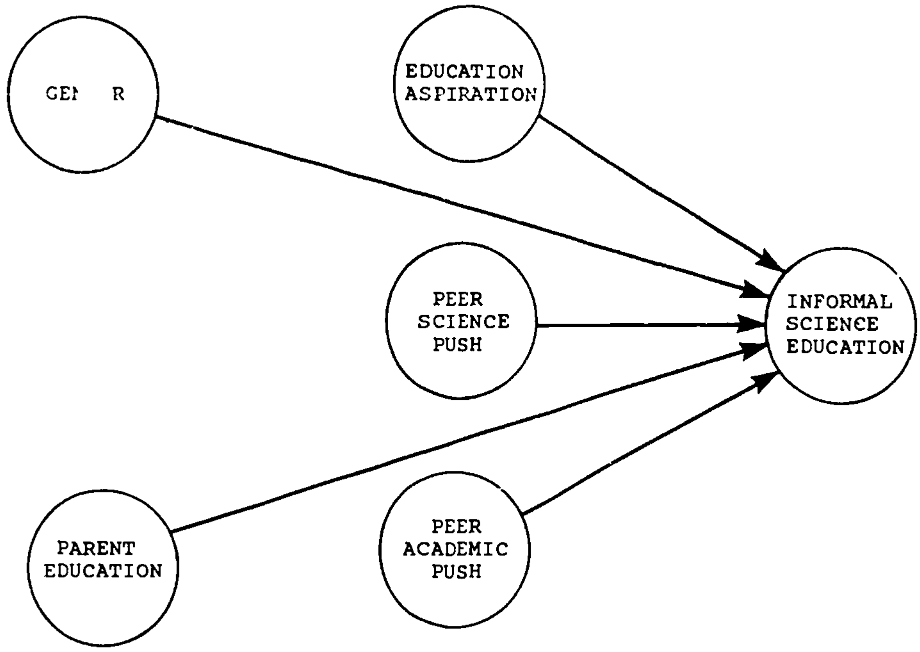


Figure 11: **A Path Model to Predict Participation in Informal Science Education, among 10th-Grade Students.**

Table 13: **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 | 287.7 | -- | .000 |
| 2. | Mutual dependence accounted for by GE. | 2 | 15.3 | .055 | .000 |
| 3. | Mutual dependence accounted for by PE. | 4 | 261.3 | .938 | .000 |
| 4. | Total mutual dependence in GP, A. | 5 | 67.9 | -- | .000 |
| 5. | Mutual dependence accounted for by GA. | 1 | 49.6 | .730 | .000 |
| 6. | Mutual dependence accounted for by PA. | 2 | 20.4 | .300 | .000 |
| 7. | Total mutual dependence in GP, S. | 5 | 11.0 | -- | .051 |
| 8. | Mutual dependence accounted for by GS. | 1 | 6.6 | .600 | .010 |
| 9. | Mutual dependence accounted for by PS. | 2 | 3.3 | .300 | .195 |
| 10. | Total mutual dependence in GPEAS, Y. | 71 | 335.6 | -- | .000 |
| 11. | Mutual dependence accounted for by GY. | 1 | 10.7 | .032 | .001 |
| 12. | Mutual dependence accounted for by PY. | 2 | 31.0 | .092 | .000 |
| 13. | Mutual dependence accounted for by EY. | 2 | 39.5 | .118 | .000 |
| 14. | Mutual dependence accounted for by AY. | 1 | 7.5 | .022 | .006 |
| 15. | Mutual dependence accounted for by SY. | 1 | 25.4 | .076 | .000 |
| 16. | MD accounted for by all 5 main effects. | 7 | 197.5 | .588 | .000 |

Legend: d.f. degrees of freedom
LRX² Likelihood-Ratio Chi-Square
CMPD Coefficient of Multiple-Partial Determination

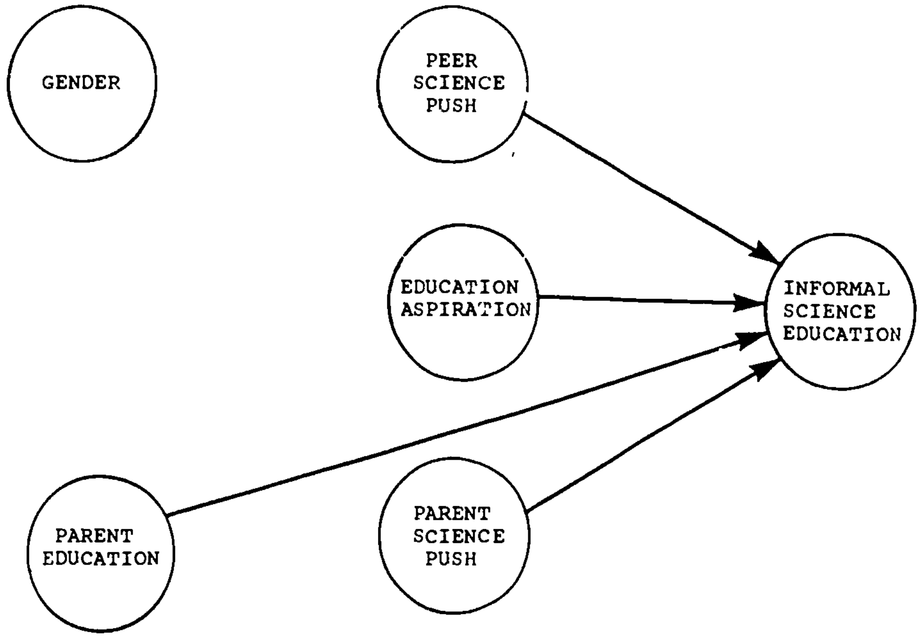


**Figure 12:** **A Path Model to Predict Participation in Infc ıal Science Education, among 10th-Grade Students.**

**Table 14:** **Some Logit Models to Estimate the Strength of Selected Paths.**

| Model | Terms | d.f. | LRX² | CMPD | P |
|---|---|---|---|---|---|
| 1. | Total mutual dependence ı GP, F. | 5 | 11.0 | -- | .051 |
| 2. | Mutual dependence accounted for by GF. | 1 | 6.6 | .600 | .010 |
| 3. | Mutual dependence accounted for by PF. | 2 | 3.3 | .300 | .195 |
| 4. | Total mutual dependence in GP, E. | 10 | 287.7 | -- | .000 |
| 5. | Mutual dependence accounted for by GE. | 2 | 15.3 | .055 | .000 |
| 6. | Mutual dependence accounted for by PE. | 4 | 261.3 | .938 | .000 |
| 7. | Total mutual dependence in GP, S. | 5 | 69.8 | -- | .000 |
| 8. | Mutual dependence accounted for by GS. | 1 | 9.7 | .139 | .002 |
| 9. | Mutual dependence accounted for by PS. | 2 | 49.1 | .703 | .000 |
| 10. | Total mutual dependence in GPESF, Y. | 71 | 370.1 | -- | .000 |
| 11. | Mutual dependence accounted for by GY. | 1 | 5.1 | .014 | .023 |
| 12. | Mutual dependence accounted for by PY. | 2 | 23.0 | .062 | .000 |
| 13. | Mutual dependence accounted for by EY. | 2 | 33.1 | .089 | .000 |
| 14. | Mutual dependence accounted for by SY. | 1 | 54.3 | .147 | .000 |
| 15. | Mutual dependence accounted for by FY. | 1 | 25.4 | .069 | .000 |
| 16. | MD accounted for by all 5 main effects | 7 | 244.2 | .660 | .000 |

Legend:
- d.f. — degrees of freedom
- LRX² — Likelihood-Ratio Chi-Square
- CMPD — Coefficient of Multiple-Partial Determination

The level of parent education also has a strong direct and indirect influence on the level of informal science education participation. The direct influence comes from the fostering of higher educational aspirations and overt science encouragement through museum visits, toys and games, and numerous other avenues. The indirect influence comes through the strong association between parent's education and peer academic and peer science encouragement. As noted earlier, this influence reflects the tendency for better educated parents to seek residences in better school attendance districts and this, in turn, assures a mix of peers that hold education in relatively higher regard and who themselves share higher educational aspirations.

As noted in the introduction to this paper, this is one of a series of base year LSAY analyses seeking to better understand the structure and development of student attitudes toward formal and informal science education. It is a first step and we look forward to sharing our longitudinal results with you in future years.