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Middle School Classroom Predictors of Science Persistence

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Abstract

Very little research has been conducted to determine whether instructional practices experienced by young adolescents have lasting effects that can be connected to persistence in the study of science years later. The current study examined the question of whether variables associated with middle school classroom practices and instructional emphasis would contribute to a prediction of science course placement in the 11th grade. A LISREL analysis was performed to create a model that ties middle school classroom experiences to later course placement. Variables associated with a holistic approach to science and with clarity of presentation were retained in the final model.

A pervasive contradiction of the modern age is that even while science and technology make some parts of daily living easier and more comfortable, it makes other aspects more complex and harder to understand. Increasingly, individuals need at least a basic understanding of science, both to stay competitive in the workplace and to understand enough about policy issues to participate in a democratic society. In recent decades, science and technology have become fused with our daily lives with an impact so pervasive that it has caused what some call a "cultural mutation" (Boulding, 1964), or at the very least a transition from an "industrial" age to an "information" age (Toffler, 1980), where data are commodities, the ability to use data well is the source of progress, and technology is the tool to unearth and relay new data. Science itself is undergoing dramatic changes in practice and theory: Traditional disciplines are becoming fused into new fields such as geophysics and biotechnology; collaboration is becoming a common mode of practice; a new wealth of scientific information causes continual shifting, revision, and replacement of scientific theory; and shift in emphasis to "science for society"—marked especially by a resurgence of research in biological fields—all keep science both intriguing and confusing to the casual observer (Hurd, 1993). Paradoxically, it is no longer advisable to be simply a casual observer of science because the transitions in science present individuals with increasingly complex decisions to make: Are nuclear power plants safe? Are low-level electromagnetic fields dangerous? Should I maintain my relative in Permanent Vegetative State? Can I retain my privacy on a cellular telephone? Should I use paper or plastic? Support owls or lumbermen? All are questions that, although new to our culture, affect an increasingly large portion of the population daily.

Unfortunately, Americans seem to understand relatively little about science—that is, they are not "scientifically literate." Results of one survey indicated that as few as 7% of adult U.S.

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citizens know enough to understand basic scientific information, a figure that has remained relatively stable over the past decade (Miller, 1992). The knowledge deficit in basic skills is so serious that many corporations have voiced concern about their ability to find capable workers (Erdman, 1993). National studies in the United States provide documentation that children, as well as adults, are unprepared to use scientific information (Jones, Mullis, Raizen, Weiss, & Weston, 1992), making it increasingly unlikely that the next generation will be better able to cope with the pace of scientific and technological growth. The combined news that the world is becoming increasingly dependent on science and technology and that the vast majority of U.S. citizens lacks basic scientific literacy has caused a resurgence of interest in the way science is taught in school. Science education is one key linchpin in the cultivation of scientific literacy; a clear relationship can be demonstrated between level of education—particularly science education—and interest in and understanding of modern social issues associated with science (Miller, 1992).

Scientists and educators alike have turned a critical eye to the schools to find out how science education might be effectively recast to create an adult citizenry capable of participating in a science-bound and technology-dependent society. Initial research revealed that the size of the student pool interested in science reaches its peak before ninth grade (Berryman, 1983). After middle school the size of the pool begins to dwindle, and the rate of attrition increases as students progress through high school and college. Although all points of this science education pipeline are important, middle school seems to be one of the nodal points during which students' interest in science can be enhanced, increasing the size of the initial talent pool.

Recognizing the importance of cultivating early interest in science, several U.S. reports have been generated containing recommendations for new directions in science education (Exxon Education Foundation, 1984; National Science Teachers Association, 1982; Rutherford & Ahlgren, 1990). Common to all of these reports is a call for students to "do science" instead of "learn science." In response to these reports, new curricula have been developed to encourage hands-on approaches and active experimentation. The motivation that drives these energetic reformers is laudable; however, report writers and curriculum developers alike are laboring with a deficit of information about the potential long-term impact of classroom practices on overall educational progress. Despite a reminder that "Before sweeping changes in curriculum are adopted, research is needed to establish the effects of content, sequence, and amount of science instruction on students' science learning" (Mullis & Jenkins, 1988, p. 15), many educators continue to rush headlong into reform without first testing their assumptions about effects of different approaches of curriculum and instruction in a larger context that includes other variables known to affect achievement and persistence.

Variables that Affect Persistence

A substantial body of research can be identified on issues related to persistence. Early achievement plays a large role in persistence, as do emotional and sociological factors. Each of these general areas—achievement, affect, and sociological—represent a range of variables that, in turn, can be connected to science persistence. What follows is a brief review of some of the key persistence variables.

Parent Education

Parent education has been demonstrated to have substantial effects on a student's long-term course-taking practices. In a study of mathematics persistence and achievement, parent education had both direct and indirect effects on attitudes toward mathematics, persistence in mathematics course-taking, and mathematics achievement (Miller, 1993). When compared to socioeconomic status, parent education emerges as at least as powerful a factor in demonstrating the impact of background environment on persistence for women and underrepresented minorities (Berryman, 1983).

Gender

The presence of gender differences favoring males in attitudes toward science and achievement in science is well documented (Oakes, 1992). Males also more frequently hold aspirations for science careers, a tendency that grows stronger as students progress through high school (K. Brown, 1992). If differences exist in attitudes, achievement, and aspirations, then it is reasonable to anticipate that gender differences in persistence will also be observed.

Student Perceptions

Past research on classroom experiences has focused primarily on the direct effects of teacher behaviors on achievement or attitudes. Recently, however, there has been a growing recognition that student cognition and affect may mediate between instruction and achievement; consequently, the perspective of students is increasingly evident in research studies (Knight & Waxman, 1991). To be consistent with this trend, any model that tests student persistence would have to include variables indicating how students respond to various classroom practices.

Instructional Method

Many studies have investigated the short-term effectiveness of a variety of instructional techniques. Whether the approach is to conduct an in-depth study of teacher–student interactions (Newmann, 1990), an anthropological study of school climate (R. Brown, 1991), an analysis of teacher behaviors (Shavelson & Stern, 1981), or a synthesis of all the available research (Walberg, 1991), a number of common techniques are repeatedly advocated as being representative of good classroom practice. Hands-on learning, inquiry-oriented instruction, problem-solving, cooperative learning, independent work, and use of well-structured texts all emerge as variables that are effective both in transmission of information and in generating motivation to learn. The tacit assumption made in many of these studies is that short-term impacts eventually translate into long-term educational advantages. Data from the National Assessment of Educational Progress (NAEP) point to a possible relationship between use of inquiry skills and higher level of science achievement (Mullis & Jenkins, 1988). Whether this relationship can be demonstrated over longer time periods, or to persistence as well as to achievement, remains to be determined.

The variables described above all relate individually to science persistence in one way or another—that much is documented in the research literature—yet none acts in isolation from the others. Each can also affect and be affected by the others, forming a complex web of interactions. To emulate through research the true individual and combined impacts of these variables in the real world, statistical analyses must reflect this complexity. A model was therefore developed testing the relationships among these variables to determine their relative contribution to the decision to persist in taking challenging science courses.

More precisely, the current analysis was undertaken to determine whether specific elements of middle school classroom experience in science could be used to predict persistence in science in the 11th grade. Middle school classroom experience in science was defined as a combination of seventh- and eighth-grade science classroom experiences as reported by students and teachers. Because school systems in the U.S. vary regarding the placement of ninth grade in either the last year of junior high school or the first year of high school, "middle school" was restricted to seventh- and eighth-grade classroom experiences. *Persistence* was defined as continued movement up the traditional hierarchy of science curriculum as evidenced by highest courses of science completed in 11th grade.

Method

Data Source

Data from the Longitudinal Study of American Youth (LSAY) at Northern Illinois University were used to conduct the analysis. The LSAY database includes a comprehensive set of variables associated with student achievement and persistence in mathematics and science. Data are gathered from a variety of sources, including students and their parents, teachers, and school principals. The study, which was initiated in 1987, has been tracking two cohorts of students: Cohort 1 (n = 2,829) consists of students who were in 10th grade in 1987 and Cohort 2 (n = 3,116) consists of students who were in 7th grade in 1987.

The two cohorts of students were constructed from a probability sample of 50 high schools and 50 middle schools throughout the United States. Students in the cohorts complete questionnaires and content-based cognitive tests in mathematics and science annually. Questionnaires elicit information regarding student attitudes toward mathematics and science, activities related to mathematics and science, and student awareness of current science and technology issues. They additionally ask students for information regarding their course-taking practices and attitudes toward their mathematics and science classes and teachers. Cognitive tests are designed to measure a variety of information and process skills associated with either mathematics or science. The science achievement test, constructed from items released from the data pool of the National Assessment of Educational Progress (NAEP), consists of three subtests: Knowledge of Science, Applications/Use of Science, and Integration of Science Knowledge. Science content areas used in the test items include life science, earth science, chemistry, and physics.

Each year the students' science teachers are asked to provide information about their science class. Information gathered from teachers includes the textbook used in the class, instructional emphasis, and time spent on a variety of classroom procedures. Teacher information is gathered from schools participating in the LSAY study ever since its inception; information is not gathered from teachers of students who moved to new schools after 1987. A more comprehensive overview of the LSAY study structure and composition can be found in the LSAY codebook (Miller, Hoffer, Suchner, Brown, & Nelson, 1992).

The focus of this study is on Cohort 2. Six years of data have been gathered associated with the education of these students, allowing for substantive analysis of the long-term effects of a variety of educational practices. Only students with complete data records for the variables associated with the study were included in the analysis. Students who were not taking science in either 10th or 11th grade were also excluded from the analysis, yielding a total sample of 1,166 students.

Variables in the Model

Dependent Variable. If middle school classroom experiences are effective and positive, it is reasonable to expect that consequences would be (1) continued enrollment in science courses

Table 1
Highest Science Course Completed by 11th Grade

Course name	Response (%)
General science/lab	10.1
Biology	32.8
Chemistry	43.4
Physics	13.7

and (2) enrollment in courses that move students to higher levels of science. Both elements were integrated to form the construct *science persistence*.

Science persistence was defined as the highest level of science that a student completed by the first semester of 11th grade. "Highest level science class" was determined by comparing the science courses that students reported taking in 11th and 10th grade. If the 11th-grade course was higher in the traditional science sequence, then it was used as the highest level of science. If a student took a higher level of science in Grade 10 than in Grade 11, or if the student was not enrolled in any science course in Grade 11, the highest course from 10th grade was used as the current highest level of science. Students who were not enrolled in science in either 10th or 11th grade were not included in the analysis. Table 1 presents the percentage of students in the sample enrolled at each level of the hierarchy.

Independent Variables: Student Background. Parent education (PEDUC) was included as an exogenous variable under the assumption that it would have a similar impact as evidenced in previously cited studies of science achievement. Derived from LSAY variables MOTHED and FATHED (respectively, mother's and father's highest educational attainment), PEDUC represents the highest value educational attainment per couple. In the case of single-parent households or divorced families, the highest level of education of the primary caretaking parent was selected. The distribution of the student sample on this variable is presented in Table 2.

Gender was used as a second exogenous variable to account for possible differences between males and females in their science achievement and science attitudes prior to the seventh grade. The sample includes 49.6% male students and 50.4% female students.

Independent Variables: Middle School Classroom Experiences. Middle school variables in the model were selected from various sources, each of which reflects a different aspect of the classroom experience: teachers, students, and records of science achievement.

Table 2
Highest Parent Education Levels

Level of education	Response (%)*
Less than high school	5.7
High school diploma	50.4
Associate degree (2-year)	11.9
Baccalaureate degree	17.2
Master's degree	10.2
Ph.D./Professional degree	4.7

*Total exceeds 100% due to rounding error.

Student Questionnaire Responses

Student perceptions of their middle school classes were gathered from two scales included on the bi-annual LSAY student questionnaire. The first scale consisted of items associated with the structure of the course and the second scale asked students to respond to questions about their science teacher. After equating the items of the scales for range of response, they were combined for a principle component factor analysis. Four reliable factors emerged from this analysis: (1) *intellectual accessibility* (ACCESS), or the degree to which students found the course easy to follow and comprehend; (2) perceived *teacher enthusiasm* (TENTHU), which described the degree to which students found their teachers effective; (3) *teacher academic push* (TPUSH), an index of students' perception that their science teacher encouraged achievement, and (4) *teacher career push* (CPUSH), consisting of students' perceptions of the teacher's expectations relating to specific encouragement of a science career. Student responses to the individual items associated with each of these factors are presented in Tables 3–6.

Teacher Questionnaire Responses

Information about teacher classroom practices was drawn from a single subscale on the teacher questionnaire. Items on the questionnaire asked teachers where they placed their instructional emphases. When submitted to a principle component analysis, two factors with suitable reliabilities were extracted: emphasis on *inquiry and science-process skills* (INQUIRE), which grouped several kinds of scientific skills, including process, inquiry, problem-solving, and technical skills; and emphasis on *reading biographies of scientists* (BIO), which combined all of the items related to the study of interesting persons and events in science. Individual items representing teachers' *emphasis on facts and principles* (FACT7 and FACT8) were also included. Teacher responses to individual items in the factors are presented in Table 7.

Student achievement scores for the seventh-grade administration of the LSAY Science Cognitive Test (ACHIEVE7) were included to account for the effects of early achievement on persistence and to determine whether the effect of the instructional variables is entirely subsumed under the historically strong relationship between persistence and prior achievement.

Table 3
Student Perception of Teacher Enthusiasm (TENTHU) (alpha = .73)

	Response distribution (%)*		
Item	True	Not sure	False
Teacher Enthusiasm: Grade 7			
My teacher is a very good teacher	61.4	22.5	16.1
My teacher really enjoys teaching science	57.6	7.6	34.8
My teacher really seems to like me	42.8	22.1	35.0
My teacher gives me extra help when I don't understand something	49.3	36.4	14.3
Teacher Enthusiasm: Grade 8			
My teacher is a very good teacher	61.2	20.1	18.6
My teacher really enjoys teaching science	65.2	3.8	31.0
My teacher really seems to like me	41.8	19.1	39.1
My teacher gives me extra help when I don't understand something	51.0	34.5	14.4

*Percentage may not equal 100% for each item due to rounding error.

Table 4
Student Perception of Intellectual Accessibility (ACCESS) (alpha = .75)

Item	Response distribution (%)*		
	Positive	Neutral	Negative
Accessibility: Grade 7			
How much do you like the subject matter of the course?	69.3	16.5	14.2
How clear is the teacher in explaining the material?	79.8	10.4	9.8
How difficult or easy is (this) course for you?	62.2	20.1	17.7
How clear is the textbook for (this) course?	77.5	12.4	10.1
How useful do you think this course will be to you in your career?	66.1	15.2	18.7
Accessibility: Grade 8			
How much do you like the subject matter of the course?	59.0	21.1	19.9
How clear is the teacher in explaining the material?	74.3	13.6	12.1
How difficult or easy is (this) course for you?	62.4	22.1	15.5
How clear is the textbook for (this) course?	78.7	13.2	8.1
How useful do you think this course will be to you in your career?	63.1	14.2	22.6

*Percentage may not equal 100% for each item due to rounding error.

Table 5
Student Perception of Teacher Career Push (CPUSH) (alpha = .70)

Item	Response distribution (%)*		
	True	Not sure	False
Career Push: Grade 7			
My teacher has encouraged me to think about a career in math or science	13.7	70.6	15.7
My teacher has encouraged me to take all the science I can get in school	24.7	52.6	22.7
My teacher has talked to me about the kind of job I might want to do	8.2	85.6	6.2
My teacher expects me to go to college	21.2	25.4	53.4
My teacher encourages me to do extra work when I don't understand something	31.7	41.5	26.8
Career Push: Grade 8			
My teacher has encouraged me to think about a career in math or science	13.5	68.5	18.0
My teacher has encouraged me to take all the science I can get in school	29.1	50.2	20.7
My teacher has talked to me about the kind of job I might want to do	10.7	82.6	7.3
My teacher expects me to go to college	23.0	24.0	53.0
My teacher encourages me to do extra work when I don't understand something	32.8	41.3	25.9

*Percentage may not equal 100% for each item due to rounding error.

Table 6
Student Perception of Teacher Academic Push (TPUSH) (alpha = .67)

Item	Response distribution (%)* True	Not sure	False
Academic Push: Grade 7			
My teacher expects me to work hard on science	75.9	7.4	16.7
My teacher expects me to do my best all the time	79.0	6.8	14.2
My teacher expects me to complete my homework every night	87.6	6.2	6.2
My teacher thinks that it is very important that I do well in science	67.2	11.1	21.6
Academic Push: Grade 8			
My teacher expects me to work hard on science	77.8	5.6	16.6
My teacher expects me to do my best all the time	81.5	4.7	13.9
My teacher expects me to complete my homework every night	89.2	4.5	6.3
My teacher thinks that it is very important that I do well in science	65.9	8.5	25.6

*Percentage may not equal 100% for each item due to rounding error.

Data Analysis. Teacher or student ratings were calculated by taking the average combined score for the items on each scale. A middle school score was calculated by then averaging the seventh- and eighth-grade scores. The only variables that were not averaged were FACT7 and FACT8 (emphasis on facts and principles), where the alpha coefficient for the combined items was too low to justify averaging the scores. Figure 1 provides a representation of the model as it was originally formulated for analysis.

The model was tested using linear structural relations (LISREL), which is designed to test structural equation models (Joreskog & Sorbom, 1988). Unlike regression analysis, which allows only assessment of the relationship between independent variables with the dependent variables, LISREL tests the simultaneous fit of the entire system of interactions represented in the model, resulting in estimates that are more reflective of real relationships and interrelationships among all variables. Other advantages of using structural equation modeling are the ability to estimate measurement errors in both dependent and independent variables, assessing the degree of fit between latent variables and their behavioral indicators, and measuring the interdependence of variables (Joreskog & Sorbom, 1988). Explanations of the theory and practice of using structural equations in the social sciences can be found in detail elsewhere (Bentler, 1986; Hayduk, 1987). To account for the restricted variances and covariances of the ordinal variables included in the study, the raw data were first converted into a polychoric, polyserial correlation matrix using the PRELIS preprocessor for LISREL (Joreskog & Sorbom, 1988), which was then read into LISREL.

Results

A LISREL analysis was conducted to estimate the conceptual model testing the effects of middle school experiences on 11th-grade science course placement. The resulting model had an

Table 7
Instructional Emphases of Middle School Science Teachers

Item	Response distribution (%)*		
	Mild	Moderate	Strong
Inquiry-Based Instruction (INQUIRE) (alpha = .79)			
Grade 7			
Developing problem-solving/inquiry skills	17.1	53.0	29.9
Develop skill in lab techniques	42.5	38.5	19.0
Developing scientific writing skills	60.7	29.1	10.2
Developing systematic observation skills	9.3	64.4	26.3
Teaching applications of mathematics in science	71.7	20.5	7.5
Teaching experimental logic and design	35.7	51.6	12.7
Grade 8			
Developing problem-solving/inquiry skills	14.2	61.2	24.6
Developing skill in lab techniques	42.5	38.5	19.0
Developing scientific writing skills	64.2	27.1	8.7
Developing systematic observation skills	18.1	61.7	20.2
Teaching applications of mathematics in science	56.1	36.5	7.5
Teaching experimental logic and design	36.1	41.1	22.8
Study of Biographies (BIO) (alpha = .63):			
Grade 7			
Biographies of scientists	84.6	14.8	0.6
Women in science	95.9	3.5	0.6
General interest in science	1.3	48.9	49.8
Grade 8			
Biographies of scientists	92.2	7.5	0.3
Women in science	93.1	6.9	0.0
General interest in science	9.5	52.8	37.7
Facts and Principles (FACT7 and FACT8):			
Grade 7	0.7	38.2	61.1
Grade 8	4.6	36.9	58.5

*Percentage may not equal 100% for each item due to rounding error.

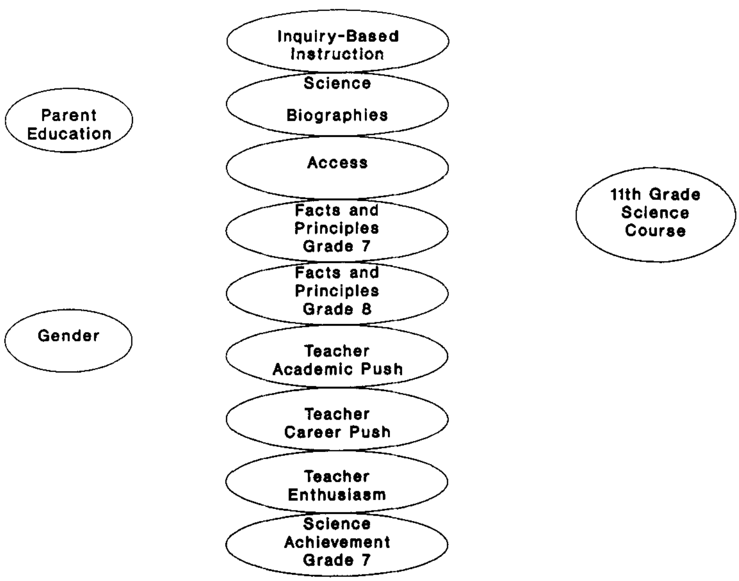

Figure 1. Conceptual model for analysis of science persistence.

Table 8
Correlation Matrix Used in the LISREL Analysis

	PEDUC	GENDER	INQ	BIO	TENTHU	FACT7	FACT8	ACHIEVE7	COURSE11
PEDUC	1.00								
GENDER	.00	1.00							
INQ	.13	.04	1.00						
BIO	−.13	.03	.26	1.00					
TENTHU	.02	−.02	.13	.16	1.00				
FACT7	.05	.07	−.01	.08	.11	1.00			
FACT8	.05	.02	−.26	.16	−.21	.03	1.00		
ACHIEVE7	.32	.12	.17	.10	.09	.18	.03	1.00	
COURSE11	.36	.06	.28	.21	.10	.08	.02	.48	1.00

PEDUC = Parent education; INQ = Inquiry-based instruction; BIO = Study of people and events influencing science; TENTHU = Teacher enthusiasm; FACT7/FACT8 = Emphasis on facts and principles in Grade 7 or 8; ACHIEVE7 = Science achievement test score in Grade 7; COURSE11 = Highest science course completed through Grade 11.

Adjusted Goodness of Fit of .98, a Root Mean Square Residual of .03, and $\chi^2/df = 2.36$ ($\chi^2 = 33.08$, $df = 14$). All of these figures represent significant values within acceptable ranges. The squared multiple correlation of the structural equation (R^2) for the outcome variable was .46. Relationships among the variables used in the final equation are presented in the correlation matrix in Table 8.

Figure 2 presents the final model estimated in the analysis. Background characteristics are placed at the left of the model, and causal relationships are implied as the diagram is read from the left to the outcome (dependent) variable on the right. The path values shown on the chart are standardized Beta coefficients, which are significant at the .05 level or better. Nonsignificant paths are not shown; variables that did not contribute significantly to the final predication model are also not shown. Direct and indirect effects of the variables in the final model are presented in Table 9.

Effects of Background Variables

Parent education and gender both had modest but significant effects on the outcome variable, science persistence, in Grade 11. The direct effect of parent education (PEDUC, .12) was only slightly higher than was gender (.10).

Parent education had significant effects on middle school science inquiry and process skills (INQUIRE, .14), study of science biographies (BIO, −.18), and seventh-grade science achievement (ACHIEVE7, .36). According to this model, well-educated parents are more likely to actively seek placement for their children in classrooms that emphasize a hands-on approach to science and where the emphasis of the classroom is on science content rather than science history. The combination of direct and indirect effects results in a total effect of .37 for parent education.

Gender had a significant effect on only one middle school variable, namely seventh-grade science achievement (ACHIEVE7, .15). The direction of this correlation is consonant with the widely observed gender gap favoring males' science achievement, although the magnitude of the coefficient suggests that the size of the gap may be somewhat smaller than has been historically reported in the literature. The total effect of gender in the model was .16.

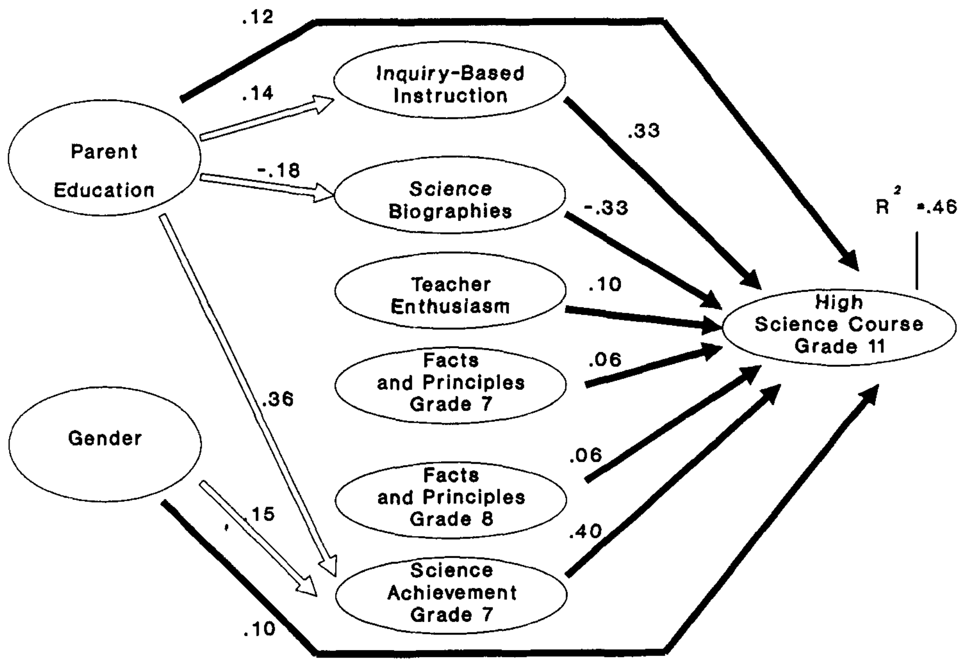

Figure 2. Structural equation model to predict science persistence in 11th grade.

Effect of Independent Variables Describing Students' Perceptions of Their Science Class

Of the original factors describing students' perceptions only one, teacher enthusiasm (TENTHU), remained in the final equation (.10). Student ratings on the variables intellectual accessibility (ACCESS), teacher academic push (TPUSH), and teacher career push (CPUSH) did not contribute significantly to the prediction of 11th-grade course placement. The low but significant contribution of teacher enthusiasm to the model suggests that students' perceptions of teachers' attitudes toward teaching science and toward individual students may play a part in their decision to continue in science.

Table 9
Direct, Indirect, and Total Effects of Factors on 11th-Grade Science Course Placement

Independent variable	Direct effects	Indirect effects	Total effects
PEDUC	.12	.25	.37
GENDER	.10	.06	.16
INQUIRE	.33	.00	.33
BIO	.33	.00	.33
TENTHU	.10	.00	.10
FACT7	.06	.00	.06
FACT8	.06	.00	.06
ACHIEVE7	.40	.00	.40

Effect of Independent Variables Describing Teacher Emphasis in the Classroom and Prior Achievement

All of the factors describing instructional emphases in middle school had significant paths to science persistence in 11th grade. Although 7th-grade science achievement was the primary influence on 11th-grade science persistence (.40), use of inquiry-based instruction and science process skills (INQUIRE, .33) was also a strong indicator of students' later placement in high-level science courses. Interestingly, teachers' reported emphasis on scientific facts and principles in either Grade 7 (.06) or in Grade 8 (.06) made a much less substantial contribution to 11th-grade course placement than did instructional emphasis on inquiry and science process skills. Even when taken together, the combined impact of these two variables was less than half of the impact of inquiry-based instruction.

Discussion

Parent education and gender had both direct and indirect effects on the model. The present findings provide further substantiation of the important role that parents play in determining their children's education. The effect found for gender is representative of other data in the literature, which indicates a gender gap in science that is diminishing but still measurable (Oakes, 1992).

One of the most heated debates in science education, and indeed in education in general, is whether the curriculum should emphasize depth of understanding or breadth of coverage. Many fear that if time is spent on hands-on learning or other inquiry-based approaches, students will not learn sufficient information to prepare them for subsequent study. Although it was not surprising to find that an emphasis on facts and principles contributed to science persistence, it was surprising to learn that emphasis on inquiry-based instruction and science process skills was also significant, and had stronger—more than double—predictive value. The relative strength of inquiry/process-based instruction is interesting, especially considering it was included among historically strong predictors such as parent background and prior achievement. Both the presence and the strength of this variable provide a powerful argument for those who advocate making science both active and student friendly. This is because inquiry seems to lead to later enrollment in higher levels of science. Science-reform efforts, notably *Project 2061: Science for All Americans* (Rutherford & Ahlgren, 1990) and the National Research Council's *National Science Education Standards* (1993), advocate a new curriculum with less emphasis on content coverage and more emphasis on taking the time to allow students to become immersed in the process of investigating a science issue in depth. Findings from the current study suggest that this approach could lead to increased persistence in science studies.

Teachers also make a difference, as suggested by the low but significant contribution of students' perception of teacher enthusiasm in the model. This factor was comprised of the following questionnaire items (answered True, False, or Not Sure):

> My teacher is a very good teacher.
> My teacher really enjoys teaching science.
> My teacher really seems to like me.
> My teacher gives me extra help when I don't understand something in science.

Evidently, a student who perceives that he or she is liked and important is more likely to continue in science than is a student in a more impersonal classroom environment. Also, a part of this factor was the students' perception that their teacher enjoys science and is skilled in instruction: The perception that a teacher finds the subject matter interesting may enhance students' interest to the point that it may play a part in later decisions about future course selection. The presence of teacher enthusiasm in the final model also reaffirms the importance of considering how students perceive their educational experience along with variables describing teacher practices and/or objective classroom analysis.

Taken as a whole, the model provides some interesting contrasts and new perspectives on the importance of classroom practices. According to this model, conscious efforts to emphasize facts and principles, though not unimportant, may be relatively *less* important than having students experience the "ethos" of science and become competent in scientific-process skills. The predictive value of instructional emphasis on inquiry and process skills in middle school was comparable to parent education and seventh-grade achievement, variables that consistently have played substantive roles in predicting later achievement. The only variable with a negative coefficient in the model was study about scientists (BIO), which had a predictive value equal to that of inquiry-based instruction, in the reverse direction (−.33). Upon consideration, the instructional practices represented by the two factors are clearly quite different: While students are participating in scientific problem-solving or experimentation, they are still immersed in science and scientific data; they are learning the content of the curriculum. However, in taking time out to study about scientists, male or female, students are taken away from hard-core science content. If one assumes that it is this fact-based content that determines later placement, it is reasonable to assume that time spent on biographies may actually impede the course of learning real science, or at least militate against enrollment in subsequent courses.

Most important, perhaps, is the global finding that what happens in early schooling does have a direct and substantive impact on later education. Although this model, with an R^2 of .46, leaves much of the variance unexplained, it also demonstrates that the day-to-day interaction of middle school teachers and students is more than transitory or short-lived. The cultivation of interest in science in middle school may have a substantive effect on how far students choose to pursue science in school.

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