Educational Productivity Predictors Among Mathematically Talented Students

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ABSTRACT **Walberg (1984) identified nine correlates of the educational achievement displayed by students in the United States and in a dozen other countries and called them "productivity factors." Using data from the Study of Mathematically Precocious Youth's longitudinal survey of its students 10 years after identification, we tested five of the productivity factors for their ability to predict educational achievement and educational and career aspirations of mathematically talented students. We also examined the validity of the prevailing belief that gifted children achieve highly regardless of the educational experiences provided. Thirteen-year-old students (1,247) in the top 1% to 2% nationwide in ability were followed until age 23. Students' achievements and aspirations were uniformly high at that time. Nonetheless, the five productivity factors could significantly predict their educational achievements and aspirations. The predictors were, in order of usefulness, quality of instruction, home environment, motivation, ability, attitudes, and quantity of instruction. Generally, the productivity factors appeared to operate similarly for males and females, but had stronger impacts on female aspirations. The results indicate that, even among gifted students, environmental interventions may enhance educational achievement, especially that of females.**

The performance of American students in mathematics and science has recently received considerable publicity and is of national concern (Byrne, 1989a, b). Relative to students in other nations, especially Japan, American youth have scored poorly on standardized achievement tests (e.g., Comber & Keeves, 1973; LaPointe, Mead, & Phillips, 1989; McKnight, Crosswhite, Dossey, Kifer, Swafford, Travers, & Cooney, 1987; Stevenson, Lee, & Stigler, 1986; Stevenson, Stigler, Lee, Lucker, Kitamura, & Hsu, 1985; Uttal, Lummis, & Stevenson, 1988; Walberg, Harnisch, & Tsai, 1986). The U.S. students' poor international standing is first evident in the primary grades; it then deteriorates further with successive grades (Stevenson, 1983; Stevenson et al., 1985). Can something be done to improve the scores that American children earn on achievement tests? Current data suggest that the answer is yes. Stevenson and colleagues, for example, have found that early environments influence subsequent achievement and that those environmental factors operate similarly among different cultures. Stevenson and colleagues also found, in contrast to Lynn (1982), that intellectual ability did not account for cross-cultural differences in performance.

As a consequence of the above findings, public attention has been focused on the quality of American schools. Several national organizations have formulated reports citing shortcomings in the American educational system (American Association for the Advancement of Science, 1982; National Commission on Excellence in Education, 1983; National Research Council, 1989; National Science Board, 1983). Various suggestions for increasing the effectiveness of American schools also were put forth. Further, Walberg (1984) analyzed national and international data banks and identified nine factors that correlate with achievement and attitudes of school children. Those productivity factors were ability, age, motivation, amount and quality of instruction, home and classroom environment, peers, and television. Walberg's model of educational productivity is basically an expansion of the Carroll (1963) model of school learning, but it makes explicit reference to the social environment of the

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classroom, the student's home environment, peer influences, and the effects of mass media (Carroll, 1989).

In a review, Pascal and Starhia (1989) found support for Walberg's productivity factors. Regression weights were tabulated from 23 different cross-sectional studies that tested the productivity factors, using random national samples from the National Assessment of Educational Progress (NAEP, 1979), High School and Beyond (Peng, Fetters, & Kolstad, 1981), and the International Association for the Evaluation of Educational Achievement (IEA; Husen, 1967). Of the 376 coefficients, 326 (87%) were in the expected positive direction; that is, the coefficients indicated that productivity factors correlated positively with achievement. The one exception was, as had been predicted, weekly hours of television.

Walberg and colleagues analyzed only average-ability samples. Individuals with the most potential for high academic achievement in mathematics and science, however, are generally in the top few centiles in ability, especially mathematical ability (Davis, 1965; Green, 1989; Walberg, Strykowski, Rovai, & Hung, 1984; Werts, 1967). Yet, we believe that even those students require stimulation and appropriate educational experiences in order to achieve at a high level in science. If the educational experiences of mathematically talented children do not maximize their potential, the United States loses an important national resource (Horowitz & O'Brien, 1986; Mumford & Gustafson, 1988). Apparently, our best students are not being adequately challenged in science. Many potential scientists are lost to business, and a future shortage of scientists is anticipated (National Science Board, 1983; Office of Technology Assessment, 1988).

Can the productivity factors enhance educational achievement and aspirations of mathematically talented youth? The prevailing belief is that gifted children achieve highly regardless of the educational experiences provided. Is there validity to this viewpoint? In our study, we used longitudinal (10 year) data collected in the Study of Mathematically Precocious Youth (SMPY) to explore this possibility. The use of longitudinal rather than cross-sectional data, as reported on previously by Walberg and others, is a more powerful test of the utility of productivity factors. Thus, we extended Walberg's earlier findings. We assessed whether productivity factors are also productivity predictors. Finally, we determined whether productivity factors operate similarly for males and females.

Most SMPY participants have exhibited high levels of achievement (Benbow, 1983; Benbow & Arjmand, 1990). For example, 85% of the students in one SMPY sample (the 1,247 students we studied) had completed college (usually selective colleges) and almost half had graduated in the top 10% of their classes. In essence, we investigated whether productivity factors were related to high levels of academic achievement among mathematically talented males or females. Our prediction was that they would be related.

Methods

Subjects

Intellectually talented students were identified by SMPY, which administered the College Board Scholastic Aptitude Test (SAT) to intellectually able 12- to 13-year-old children (Keating & Stanley, 1972). Over 12 years, more than 10,000 preadolescents (mostly 7th graders) participated in SMPY talent searches. SMPY's longitudinal study, located at Iowa State University, is tracking four cohorts of gifted students identified in the 1970s and 1980s.

Students in Cohort 1 of SMPY's longitudinal study, who constituted the sample in this investigation, were drawn from SMPY's first three talent searches (i.e., 1972, 1973, & 1974). In those searches, 7th and 8th graders in Maryland were eligible to participate if they had scored in the upper 5% (1972) or upper 2% (1973, 1974) nationally on any standardized mathematics achievement test. Qualified students took the College Board Scholastic Aptitude Test-Mathematics (SAT-M) and, in 1973, also the SAT-Verbal (SAT-V). Those tests are designed to measure, respectively, developed mathematical and verbal reasoning ability or aptitudes of high school students, although some consider the SAT to be partly an achievement measure. Researchers believe, however, that the SAT is a more potent measure of reasoning for 7th and 8th graders than for 11th and 12th graders (Minor & Benbow, 1986; Stanley & Benbow, 1986).

Scores of at least 390 on SAT-M *or* 370 on SAT-V in the 7th or 8th grade were required for inclusion in Cohort 1 of the longitudinal study. Those SAT criteria selected 2,118 students who, as 7th or 8th graders, scored as well as the average high school female; it also provided a wide range of SAT performance to study. For males at age 13, mean SAT scores, which had been grade adjusted (see Benbow and Minor, 1986), were 556 (SD = 73) on SAT-M and 436 (SD = 85) on SAT-V. For females, they were 519 (SD = 59) on SAT-M and 462 (SD = 88) for SAT-V. Approximately 4 years later, in high school, the mean scores for Cohort 1 had increased to 695 (SD = 70) on SAT-M and 593 (SD = 88) on SAT-V for males. For females, the mean scores had increased to 650 (SD = 71) on SAT-M and 599 (SD = 89) on SAT-V.

Procedure

All talent-search participants completed a background questionnaire before they took the initial SAT at age 12 through 14. Students in Cohort 1 were first surveyed at age 18 (91% response rate) (Benbow, 1983; Benbow & Stanley, 1982a). A second follow-up survey with a

24-page printed questionnaire[2] was administered at age 23. Procedures used in the second survey were the same as those used in Benbow and Stanley (1982), except that no monetary incentives could be offered. Surveys were mailed to students in 3 successive years to ensure that all individuals were of the same age when completing the survey. The initial response rate to the second follow-up was 65%. The viability of a longitudinal study depends upon retaining a large proportion of the original sample, so nonrespondents were surveyed by telephone with 20 critical questions, increasing the response rate to over 70%. The sample included 786 males and 461 females.[3]

Discriminant analyses were computed separately for males and females to determine if nonrespondents differed from respondents on the basis of 8th-grade SAT-M score, high school SAT-M and SAT-V, college attendance, quality of college attended, parental educational levels, number of siblings, and fathers' occupational status. No statistically significant differences existed between respondents and nonrespondents.

The variables used in this study reflected the five productivity factors (see Table 1). The SMPY longitudinal study, however, was not designed with the intent of testing the author's (Walberg, 1984) productivity theory.

Table 1.—Descriptive Statistics for Predictor Variables and Outcome Measures and Their Correlation

Variables	*M*	*SD*	Educational achievement	Educational status	Educational aspirations	Career aspirations	Rank in class (college)
Outcome measures							
Educational achievement	2.95	.86		.60	.53	.18	.11
Educational status	5.21	1.65	.60		.64	.30	.16
Educational aspiration	4.27	.76	.53	.64		.38	.14
Career aspiration	63.47	29.36	.18	.30	.38		.13
Rank in class (college)	3.08	.92	.11	.16	.14	.13	
Ability							
Talent search SAT-M	541.61	70.13	.15	.17	.15	.06	.04
High school SAT-M	677.10	72.26	.14	.21	.21	.08	.07
High school SAT-V	594.67	86.64	.11	.17	.22	.09	.16
Motivation							
Mathematics & science	1.56	1.67	.21	.28	.27	.17	−.03
No. of academic activities in high school	1.46	1.60	.06	.04	.08	.04	.17
Quality of instruction							
Special program participation	.39	.91	.02	.09	.11	.14	.02
Acceleration	2.95	1.02	−.08	−.01	−.05	.01	−.05
No. of AP courses	.74	1.23	.18	.24	.26	.14	.04
Calculus (taken)	.56	.58	.13	.17	.14	.08	.05
Physics (taken)	.69	.46	.14	.18	.19	.12	−.01
No. of academic awards	2.52	3.00	.09	.12	.13	.09	.14
Quantity of instruction							
Semesters of mathematics	8.93	2.53	.14	.14	.13	.07	−.01
No. of science courses	3.81	1.32	.14	.18	.18	.13	−.01
Significant person or event							
Beneficial	.35	.65	−.00	.06	.08	.11	.00
Harmful	.09	.33	−.12	−.11	.01	−.02	−.02
Family background							
Father's education	4.33	1.88	.18	.20	.23	.08	.01
Mother's education	3.30	1.38	.13	.13	.20	.07	−.01
Father's occupational status	77.77	8.14	.19	.21	.19	.10	−.00
Number of siblings	2.34	1.57	−.02	−.06	−.06	−.04	−.01
Sibling position	2.10	.129	−.03	−.02	.04	−.02	−.02
No. of awards won by relatives	.48	.96	.07	.10	.22	.10	.05
Family encouragement							
Mathematics	2.99	.77	.02	−.01	.02	.06	−.05
Science	2.87	.77	.07	.09	.10	.11	−.04
College attendance	3.72	.57	.22	.22	.16	.08	.00
Career & educational goals	3.03	.89	.11	.14	.09	.12	.05
Student attitude							
Mathematics	4.05	.56	−.02	−.01	−.01	.03	−.05
Science	3.73	.73	.06	.09	.18	.12	.01
Gender (male = 1, female = 0)	.62	.49	.02	.06	.14	.04	−.11

Thus, our productivity factors were operationalized using available SMPY data (see the Appendix for variables and their coding). The rationale for selecting each variable as an indicator of a productivity factor should be self-evident, except perhaps for the inclusion of taking calculus or physics as a quality (rather than quantity) of instruction factor. Because physics and calculus are not offered by all high schools, especially not in the mid-1970s, but rather by the best schools, we felt that it was more appropriate to include those two variables under the quality rather than quantity of instruction productivity factor. Not all the students had the opportunity to take physics or calculus.

The SMPY data bank included no information on television viewing, peer group environment, and classroom environment. Moreover, development (i.e., age) was constant. Thus, the analyses included measures of the following productivity factors only: ability and motivation, quality and quantity of instruction in high school, and family environment. We also included measures of attitudes and gender in our analyses because of their demonstrated impact on achievement. Although attitudes may be viewed as a component of motivation, we analyzed their relationship to achievement separately. Thus, seven sets of variables were used to predict, at age 23, the students' educational achievement, status, and aspirations; career aspirations as measured by the Duncan-Siegel scale; and rank in college graduating class.

Results

Table 1 provides descriptive statistics for each of the outcome measures and productivity factors (i.e., means, standard deviations, and Pearson correlation coefficients between predictor and outcome measures). On the outcome (i.e., achievement) measures studied, students were generally in the top range (see Table 1). For example, by age 23, almost all the students were college graduates. The larger correlations with achievement and aspirations were generally for motivation, number of advanced placement (AP) courses,[4] and family background and encouragement.

Table 2 shows the prediction results obtained when the achievement and aspiration variables were related to the whole set of 28 predictors by use of multiple regression. The backward elimination method successively dropped from the full regression model, which contained all predictors, the weakest predictors, until only those with statistically significant ($p \leq .05$) regression weights remained. In addition to the beta weight, the raw regression weight, b, is shown. When the other independent variables are held constant, the b statistic indicates the number of units of change in the outcome measure associated with a one-unit change in the independent variable.

The multiple correlation between the full set of predictor variables and outcome measures ranged from .29 to .47. Thus, the amount of explained variance was not large, as had been anticipated. Cohort 1 students were, for the most part, all achieving highly, and they had high aspirations (see Table 1 and Benbow & Arjmand, 1990). Thus, there was considerable restriction of range in the outcome measures, as well as in some of the predictor variables.

The largest multiple R was obtained for educational aspirations and educational status, a finding that was not surprising. As mentioned earlier, most students had graduated from college with outstanding academic records. Thus, there was not much variance to be accounted for in the educational achievement and rank in graduating class measures.

Two sets of variables were basically indicators of the quality of the home environment—family background and encouragement. For all analyses, those two variables were among those with the greatest weights. Quality of instruction in high school and motivation also appeared important. The only productivity factor not significant in any of the analyses was quantity of instruction. That result may indicate that for the talented student, quality of the courses (e.g., AP calculus and physics) is more important than sheer number of courses taken. Ability and attitudes related inconsistently to achievement and aspirations; they were significant predictors in two analyses only. If subject-matter attitudes are viewed as components of motivation, however, then the apparent impact of motivation is more consistent across outcomes.

Gender differences were found for two outcome measures: males had higher educational aspirations, whereas females had better academic records in college. Although gender differences were not pervasive, the possibility that productivity factors operate differently for males and females was investigated. We therefore calculated the multiple regression analyses once more, but that time only the previously significant predictors and their interaction with gender were included as the independent variables. Each analysis included all the significant predictor variables but only one interaction term at each step. Except in the analyses where gender differences had been noted (i.e., rank in class and educational aspirations), the interactions of gender with each productivity factor were not statistically significant. Thus, gender differences in how productivity factors operate was not apparent for educational achievement and status or for career aspirations. For rank in graduating class, the interaction of gender with SAT-M score was the only significant interaction term ($p \leq .05$). Presumably, the interaction reflects the well-established gender difference in SAT-M scores, favoring males, found among the gifted (Benbow, 1988). The relationship between grades and SAT-M scores ($r = .10$) was the same for males and females.

For educational aspirations, the following interaction terms were significant ($p \leq .05$): gender and number of siblings, gender and mathematics encouragement, gender

Table 2.—Results From Multiple Regression Analyses Predicting Educational Achievement and Aspirations From Walberg's Productivity Factors

	Educational achievement			Educational status			Educational aspirations			Career aspirations			Rank in class (college)		
Productive factor	*b*	Beta	*t*	*b*	Beta	*t*	*b*	Beta	*t*	*b*	Beta	*t*	*b*	Beta	*t*
Ability															
Talent search SAT-M															
High school SAT-M				.02	.09	2.30							.01	.10	2.09
High school SAT-V							.01	.11	2.72				.01	.12	2.72
Motivation															
Mathematics and science	.08	.15	4.09	.17	.17	4.39				2.04	.12	3.09	−.07	−.12	−2.62
Number of academic activities in H.S.													.06	.11	2.53
Quality of instruction in high school															
Special program participation				.12	.07	1.94				2.68	.08	2.21			
Acceleration															
No. of AP courses							.08	.12	2.98						
Calculus taken															
Physics taken	.16	.09	2.47	.34	.10	2.75	.19	.11	2.86	4.34	.07	1.85			
No. of academic awards													.03	.09	2.07
Quantity of instruction															
Semester of mathematics															
No. of science courses															
Significant person or event															
Beneficial										2.98	.07	1.78			
Harmful	−.27	−.10	−2.98	−.45	−.09	−2.65									
Family background															
Father's education							.05	.13	3.21						
Mother's education															
Father's occupational status	.01	.10	2.68	.02	.10	2.71									
Number of siblings							−.07	−.15	−3.16						
Sibling position							.10	.17	3.62						
No. of awards won by relatives							.13	.17	4.25						
Family encouragement															
Mathematics	−.08	−.07	−2.02	−.33	−.16	−4.17	−.07	−.07	−1.77				−.09	−.07	−1.73
Science															
College attendance	.30	.19	5.12	.50	.17	4.49									
Career & educational goals				.17	.09	2.47	.08	.10	2.38	3.22	.10	2.73	.08	.08	1.86
Student attitude															
Mathematics															
Science							.13	.12	3.15	3.08	.08	2.08			
Gender (male = 1, female = 0)							.16	.10	2.62				−.18	−.10	−2.25
Full set of predictors					.44			.47			.29			.30	
Multiple *R*		.36			.19			.22			.08			.09	
R square		.14													
Reduced set of predictors					.42			.45			.26			.28	
Multiple *R*		.34			.17			.20			.07			.08	
R square		.12													

and attitude toward science, gender and encouragement for career and educational goals, and gender and SAT-V score. The interaction terms were significant, but not because males and females differed appreciably on the predictor variables. Rather, the relationship between educational aspirations and predictor variables differed for males and females. Educational aspirations most strongly related to SAT-V scores for males (.25), followed by attitude toward science (.13); whereas for females, attitude toward science (.22), encouragement for career and educational goals (.15), and SAT-V score (.19) all related significantly to educational aspirations.

Discussion

Walberg (1984) identified nine productivity factors that relate to achievement of students in American schools and in other countries. The relationships were determined using average-ability students included in cross-sectional studies. Can those productivity factors predict, 10 years after identification, the educational achievement and educational and career aspirations of mathematically talented males or females? We addressed that question using SMPY's longitudinal data bank. The predictive value of the five tested productivity factors (ability, motivation, quantity and quality of instruction, and home environment) was affirmed.

Because the students studied were, for the most part, high achievers by the end of college (Benbow & Arjmand, 1990), our study addressed differences in high achievement. Nonetheless, the productivity factors studied could predict later achievement and aspirations. The most potent factors were home environment variables, quality of instruction in high school, and motivation. The latter two factors are relatively school-alterable items (Fraser, Welch, & Walberg, 1986).

Interestingly, quality of instruction was significant, but quantity of instruction was not. We interpreted this to mean that intellectually talented students who maintained their interest in learning and pursued advanced degrees were exposed to quality educational programming. Students received relatively little benefit from taking many courses. That result supports the concept of intervention. Gifted students will not achieve as highly if not given appropriate educational opportunities.

SMPY has conducted a related study that expanded our understanding of why some mathematically talented students exhibit high academic achievement in school in mathematics and science and why some, despite their talents, do not (Benbow & Arjmand, 1990). Such high and low achievers in mathematics and science were compared on a variety of variables. Exposure to appropriate educational experiences discriminated best between such high and low achievers. Family characteristics (e.g., parental educational level and educational encouragement) were also effective in separating the two groups. Although not addressing the validity of productivity factors per se, those findings were also consistent with Walberg's (1984) productivity theory.

Underachieving gifted students tend to come from homes where the parents are not highly educated (Phye & Benbow, submitted). A study of students coming from such at-risk backgrounds has revealed that those who overcome and achieve highly were exposed to challenging educational opportunities (Phye & Benbow, submitted). The above-cited results imply that, without appropriate educational opportunities, gifted students will not achieve at their potential. This study also provides further corroboration of Walberg's (1984) productivity factors.

Although a gender difference was found in educational aspirations, favoring males, and in academic records, favoring females,[5] productivity factors did not seem to operate differently for males and females, except in the case of educational aspirations. Scores on SAT-V and attitudes toward science related significantly to aspirations for both males and females. Yet, encouragement to pursue educational and career goals also related significantly for females; and the relationship of aspirations with science attitude was stronger for females than for males. Thus, environmental factors appear to exert a stronger influence on the educational aspirations of gifted females than of gifted males. Our finding is consistent with results from Benbow and Arjmand (1990) and Albright and Benbow (in preparation). In addition, Albright and Benbow found that challenging educational experiences in science in high school relate to females choosing and remaining in a science major in college. Those results support the concept of intervention on behalf of females. Environmental manipulations should be effective in increasing the rate at which females enter mathematics and science careers.

Although quality of instruction appears to be a major influence on later achievement, the quality of the home environment appears to be at least as potent a predictor of later educational aspirations. That finding is consistent with previous research that has revealed positive impacts of the home environment on cognitive achievement, eminence, and the eventual display of talent (Albert & Runco, 1986; Benbow & Arjmand, in press; Bloom, 1985; Feldman, 1986; Fowler, 1981; Goertzel & Goertzel, 1962; Graue, Weinstein, & Walberg, 1983; Helson & Crutchfield, 1970; Iverson & Walberg, 1982; Roe, 1953; Terman, 1954; Zuckerman, 1977). The family focuses and mobilizes the individual and provides a nurturing environment (Albert & Runco, 1986). Not surprisingly, motivation, also a strong predictor in our analyses, was correlated with family background variables.

In this study, we had no data to assess the effects of leisure-time television exposure, a variable that Walberg (1984) had found to be detrimental to educational achievement. A recent study, however, has revealed that extremely precocious students watch little television (Benbow, submitted). Those students watch less than 2 hours per day, which was much less time than the amount viewed by a comparison group of modestly gifted students, and also below the level of 10 to 15 hours per week, beyond which deleterious effects of television have been noted (Williams, Haertel, Haertel, & Walberg, 1982). Moreover, it appeared that much of the time extremely gifted children did not spend watching TV was spent reading (Benbow, submitted).

Our investigations have focused on educational achievement and aspirations. Yet, existence of productivity predictors may also have implications for fostering creativity. Productivity factors should facilitate the process of acquiring general knowledge; extensive knowledge leads to the specialized mastery necessary for adult creative production. Walberg (1988), for example, estimated that to be able to accomplish the highest achievements in various disciplines requires a memory store of 1 million chunks or bits of information. To acquire this amount of information might take even a gifted individual about 70 hours of concentrated effort per week for a decade. Thus, as Gruber (1986) suggested, *much* time is necessary to become capable of creating a great work. In addition to mastering a domain's knowledge base, time is needed for practice, for movement through stages and levels of a domain (Bamberger, 1986; Feldman, 1986), for "crystallizing experiences" to occur (Walters & Gardner, 1986), and for integration and reorganization of cognitive structures (Mumford & Gustafson, 1988). Appropriate educational experiences in homes and schools, however, can facilitate and motivate such extraordinary efforts and performance. Families, schools, and universities, the chief agencies for the acquisition of knowledge and the fostering of creativity, can accomplish more of both to the extent that they are more efficient. That finding may be especially true for future scientists, who require many long years of training. Highly creative scientists also are involved in academic life at a high level when they are young (Walberg, 1988).

This study is limited by its reliance on self-report data. Moreover, the educational experiences and family characteristics were not finely detailed. Thus, we do not know the exact nature of the variables identified as being predictors of achievement. Finally, the gifted students were identified in the early 1970s and were graduated from high school during that decade. Different relationships may be found for gifted students identified and educated in later decades.

In sum, our results revealed that Walberg's (1984) productivity factors can predict achievement and aspirations of mathematically talented students. Quality of instruction and family background characteristics were the best predictors of the high academic achievement exhibited by the students 10 years later after identification. Thus, as is true for all students, highly gifted students will not achieve at their potential if their talents are not nurtured properly. Programs designed for academically advanced students do seem to have long-term benefits. Unfortunately, most gifted students do not receive an education that is commensurate with their abilities. The lack of appropriate educational programming might be the key factor explaining the large rate of underachievement among the gifted, which has been estimated at 50% (Reis, as cited in Landers, 1989).

NOTES

1. We thank Robert M. Benbow and Mary Ann Swiatek for helpful comments and suggestions. This research was funded by a grant from the National Science Foundation (MDR-8651737) to Camilla P. Benbow.
2. Copies of questionnaires used in this study can be obtained by writing to Camilla Benbow.
3. Complete data were not available for all subjects.
4. AP courses are high school courses, but the content is at the college level. They are designed for academically advanced students.
5. Kimball (1989) discusses, at length, women's consistently superior academic records in all subject areas.

APPENDIX
Variables and Their Coding

Outcome Measures

Educational achievement or aspirations

"Of the following degrees and licenses, please indicate which ones you have already earned, which ones you plan to earn."

Highest level: 1. High school diploma, 2. Some college, 3. BA or equivalent, 4. MA or equivalent, 5. Doctorate

Educational status

"What is your present educational status?"

1. Withdrawn from college, not currently enrolled, 2. Part-time undergraduate, 3. Graduated from 2-year college, 4. Full-time undergraduate, 5. College graduate, 6. Part-time graduate student, 7. Full-time graduate student

Career aspirations

"At this time, what are your long-range goals; that is, what fields do you intend to enter, what *type* of position do you intend to obtain, what ultimate *level* do you intend to reach?"

Occupational aspirations were coded using the Duncan-Siegel code.

Rank in class

"To the best of your knowledge, what was your rank in your graduating class from college or other postsecondary school?"

0. 10th (10%) 1. 9th (10%) 2. 3rd-8th (10%) 3. 2nd (10%) 4. 1st (10%)

Productivity Factors[a]

Motivation in mathematics and science

Sum of the number of mathematics contests and science fairs and the number of high school and college-level (AP) achievement tests in mathematics and science (reported at age 18)[b]

Special program participation

"Have you participated in any mathematics or science contests (such as Putnam college competition) or been awarded entry to a special honorary program (such as NSF workshops)?"

"As a child before Talent Search participation, did you receive any *special* academic training from: Parents, relatives or other adults, schools, others" (specify) in science or in mathematics? (Students answered each question with yes or no.)

Sum of the number reported

Acceleration

"Have you been accelerated in subject-matter placement?"

"Have you been accelerated in grade placement?"

"Which, if any, grades have you skipped?"

"List all the courses you took *for credit* at a college *before* becoming a *full-time* college student.

"List all Advanced Placement Program (APP) *examinations* you have taken.

"Which of the following methods did you use to accelerate your postsecondary education?"

Amount. 1. No acceleration, 2. Subject-matter acceleration, 3. College courses while in high school; advanced placement courses, 4. skipped at least one grade

Significant person or event (harmful or beneficial)

"Did any person or event have a significant influence on any educational decision?"

0. None 1. Event or person 2. Both person and event

Parental educational level

For mother or father: "Check the highest educational level . . . completed."

1. Less than high school, 2. High school degree, 3. Some college, 4. College graduate, 5. More than college, 6. MA, 7. Doctorate

Father's occupational status

"His occupation . . . Please be specific."

Responses coded using the NORC scale

Family encouragement

"Indicate the degree of encouragement you received for each of the following" from your mother and separately from your father—for studying mathematical sciences; for studying science; for going to college; for pursuing your present career and educational goals. (obtained at age 23)

Average of mother and father ratings: 0. Strong discouragement, 1. Moderate discouragement, 2. Neither encouragement nor discouragement, 3. Moderate encouragement, 4. Strong encouragement

Student attitude

Mathematics

Circle the words that *best* describe the following '. . . Your liking for arithmetic and mathematics." Very strong, Fairly strong, Slight liking, Positive dislike"

"How *important* do you think mathematics will be for the job you will someday have? Very, Fairly, Slightly, Not at all. (obtained at age 13)

"Check one of the five rating-scale categories below that most appropriately describes your attitude toward" mathematics. Strong liking, Moderate liking, Neutral or mixed feelings, Slight dislike, Strong dislike. (obtained at age 18)

Average of the three ratings: 1. Most negative attitude to 4.67. Most positive attitude

Science

"Check one of the five rating-scale categories below that most appropriately describes your attitude toward" biology, chemistry, and physics. Strong liking, Moderate liking, Neutral or mixed feelings, Slight dislike, Strong dislike (obtained at age 18)

Average of the three ratings: 1. Most negative attitude to 5. Most positive attitude

[a]Variables that are self-evident (e.g., no. of semesters of mathematics were not described. [b]The number of AP and College Board achievement tests taken by a student is an excellent measure of both motivation and educational quality. Only the best high schools offer AP courses. The most motivated students and highly achieving students in those AP courses or high school science classes take the optional AP or achievement tests.

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