DOCUMENT RESUME

ED 292 845 TM 011 225

AUTHOR	Ethington, Corinna A.
TITLE	SAT-M Performance of Women Intending Quantitative Fields of Study.
PUB DATE	[87]
NOTE	23p.
PUB TYPE	Reports - Evaluative/Feasibility (142)
EDRS PRICE	MF01/PC01 Plus Postage.
DESCRIPTORS	Academic Aspiration; *College Bound Students; College Entrance Examinations; College Mathematics; College Science; Computer Science Education; Engineering Education; Higher Education; High Schools; *Mathematics Tests; Self Evaluation (Individuals); Standardized Tests; Student Characteristics; *Womens Education
IDENTIFIERS	*Scholastic Aptitude Test

ABSTRACT

This study assessed patterns of differences in quantitative performance across groups of intended undergraduate majors consistent with those previously found for students who had completed their undergraduate study. Data were drawn from the College Board Admissions Testing Program's national sample of 10,000 college-bound high school seniors in 1982-83. The data base includes student scores on the Scholastic Aptitude Test (SAT) as well as student reported information from the Student Descriptive Questionnaire, which elicited information on students' family background, high school experiences, personal characteristics, and educational aspirations. The model for the study was estimated for 314 women who indicated their intention to major in one of the mathematical or scientific fields within the scope of the study. Women intending to major in engineering and physical science exhibited the same atypical performance. However, the large differences in mean SAT Mathematics performance found between women in mathematics, statistics, physics, and computer science versus those in engineering and the physical sciences disappeared when other measures were controlled for; and the effects of these measures were the same for both groups. Self-rating relative to others with respect to mathematics and science ability was the primary influential variable in the study. (TJH)

ED292845

SAT-M PERFORMANCE OF WOMEN INTENDING

QUANTITATIVE FIELDS OF STUDY

Corinna A. Ethington

College of Education (M/C 147)

University of Illinois at Chicago

Box 4348

Chicago, IL 60680

SAT-M PERFORMANCE OF WOMEN INTENDING

QUANTITATIVE FIELDS OF STUDY

Abstract

This study found patterns of differences in quantitative performance across groups of intended undergraduate majors consistent with those previously found for students who had completed their undergraduate study. Women intending to major in engineering and physical science exhibited the same atypical performance. However, the large difference in mean SAT-M performance found between women in mathematics, statistics, physics, and computer science versus those in engineering and the physical sciences disappeared when other measures were controlled for, and effects of these measures were the same for both groups. Self-rating relative to others with respect to mathematics and science ability was the primary influential variable in the study.

SAT-M PERFORMANCE OF WOMEN INTENDING

QUANTITATIVE FIELDS OF STUDY

The underrepresentation of women in mathematics-related fields of study and occupations has received considerable attention in the research literature. The focus of these studies typically has gone in two directions. Some work is especially concerned with the identification of factors influencing women to choose between quantitative and non-quantitative fields of study (e.g., Berryman, 1985; Peng and Jaffe, 1979; Ware, Steckler, and Leserman, 1985). Other research focuses most closely on comparisons of women and men in quantitative fields of study (e.g., Dunteman, Wisenbaker, and Taylor, 1979; Lunneborg and Lunneborg, 1985; Steinkamp and Maehr, 1984). Together these lines of research have generated a substantial body of evidence that women who major in quantitative fields are different from other women and different as well from men who major in quantitative fields. Many of the factors differentiating these women from others have also been found to influence mathematics performance.

Peng and Jaffe (1979) have shown that while many of the factors influencing the choice of a quantitative field of study are the same for men and women, family background, number of mathematics courses taken in high school, and success orientations were important for men but not for women. Lunneborg and Lunneborg (1985) also reported technical interests to be important for men and verbal abilities for women. Using meta-analytic techniques, Steinkamp and Maehr (1984) found women's achievement and attitudes toward science to be lower than men's, and differences in motivational orientations between men and women within particular areas of science. Women's orientations were found to surpass those of males in biology and chemistry, while men's orientations were higher in physics and general science. This pattern of orientations was also reported by Boli, Allen, and Payne (1985) wherein women choosing quantitative fields were found to be less likely to major in physics and engineering, preferring the life sciences. Boli, et al. (1985) also found men more likely to have taken a calculus course in high school and to have higher average SAT-M scores.

Studies examining factors influencing women's choice of a quantitative field of study have found women choosing these fields are more likely to have higher mathematics and science self-concepts (Campbell, Connolly, and Pizzo, 1986), higher educational plans (Peng and Jaffe, 1979), and taken advanced science and mathematics courses in high school (Berryman, 1985). Other influential factors are parental educational level and the desire for control, prestige, and influence (Ware, Steckler, and Leserman, 1985). Common among all of the above studies was high mathematical achievement.

The results of an exploratory analysis of Graduate Record Examination quantitative and analytical scores (Ethington and Wolfle, 1986), suggest an important third avenue of investigation: possible differences between women majoring in different quantitative fields. This exploratory study found that women who had majored in engineering and the physical sciences on the average scored higher on both the quantitative and analytical tests than would be anticipated compared with women who had majored in mathematics, statistics, and computer science. In fact, women majoring in engineering had the highest average quantitative score even though overall they had not taken the greatest number of mathematics courses. This finding may simply indicate that the more mathematically capable women elect engineering and physical science majors, or, more importantly, that the factors influencing the choice of quantitative fields of study may differentially influence mathematics performance.

The purpose of this study was two-fold. First, it was to determine if the pattern of differences seen on the quantitative Scholastic Aptitude Test (SAT-M) performance for women intending to major in quantitative fields in college was consistent with that found on GRE performance for women who did major in these areas. The second purpose was to determine if measures previously found to be associated with mathematics performance and choice of quantitative fields differed in importance and influence for women intending to major in different quantitative areas. This would be accomplished by estimating a causal model incorporating variables previously shown to influence women's selection of quantitative fields of study and measures of quantitative performance.

METHODOLOGY

Sample and Data

Data for this study were drawn from the College Board Admissions Testing Program's national sample of 10,000 college-bound high school seniors in 1982-83. This data base provides student scores from the Admissions Testing Program (e.g., Scholastic Aptitude Test verbal and mathematics scores, Achievement Test scores) as well as student reported information from the Student Descriptive Questionnaire (SDQ). The SDQ was completed by students in the sample when registering for the SAT and provides information on students' family background, high school experiences, personal characteristics, and educational aspirations.

Using the classification scheme of Ethington and Wolfle (1986), the sample was divided into seven groups that identified undergraduate majors by the level of mathematics required in the curricula. Thus, students' mathematics requirements were roughly the same within each of the seven groups. The groups of undergraduate majors were as follows: (1) mathematics, (2) statistics, physics, computer science, (3) engineering, (4) other physical sciences, (5) biological sciences, (6) social sciences, (7) humanities. The groups are ordered according to the general level of mathematics required in the undergraduate curricula.

Preliminary Analysis

In order to determine if the patterns of differences seen in mean GRE scores of women who majored in quantitative fields would also be found in mean SAT-M scores scores of women intending to major in these areas, a median polish (see Tukey, 1977) was performed on the most recent SAT-M scores of the college bound seniors. The exploratory approach of this method does not test hypotheses, but involves a decomposition of the data, producing patterns of effects that are not necessarily apparent in the summary data. This is accomplished by successively sweeping information from the original data into a common value, row effects, column effects, and residuals. The patterns seen in the data may then lead to the development of hypotheses to be subsequently tested in more rigorous statistical methods.

The mean SAT-M scores were polished across gender and intended undergraduate major groups. Table 1 gives the group and cell means as well as the results of the median polish which are generally consistent with those found by Ethington and Wolfle (1986). That is, a substantial gender effect was seen favoring males and, with the exception of the group consisting of statistics, physics, and computer science, the undergraduate group effect was positive for the more mathematically-related majors and negative for the others. The negative effect seen for the group intending to major in statistics, physics, and computer science may indicate unrealistic aspirations for those students.

Insert Table 1 About Here

The pattern of residuals for these groups of intended majors was consistent with those found by Ethington and Wolfle (1986) in GRE quantitative and analytical scores of college seniors. The residuals for women were in general negative, or when positive, low; but for women intending to major in engineering and the physical sciences, the residuals are positive and large, indicating higher scores than would be anticipated. Thus, women intending to major in quantitative areas exhibit the same patterns in quantitative performance as did women who had completed degrees in these areas.

Given the results of the median polish, a causal model was proposed in order to investigate how factors previously identified as influencing quantitative performance and selection of quantitative fields of study impact SAT-M performance and to determine whether the effects of influential variables were the same for women in different quantitative areas.

The Model

The causal model proposed for this study incorporated factors indentified in previous studies that were found to be related to quantitative performance and women's selection of quantitative fields of study. Performance on the SAT-M was considered to be a function of student background (e.g., race, mother's and father's education, income), measures of academic and extracurricular involvement (e.g., number of science and mathematics courses taken, advanced courses taken, extent of extracurricular involvement), academic achievement (e.g., mathematics and science grades), student's ratings of abilities (e.g., mathematics and science abilities, leadership abilities), and intended undergraduate major. These blocks of variables were incorporated into a block-recursive causal model ordered in the above sequence. The data used for the estimation of the model was obtained from the Student Descriptive Questionnaire, and operational definitions for the variables are given in Table 2. The model was estimated for the 314 wonen who indicated their intentions to major in mathematics, statistics, physics, computer science, engineering, or other physical sciences.

Insert Table 2 About Here

<u>Model Estimation</u>

Prior to the estimation of the model, a series of tests were run to determine if the variables in the model exerted differential effects on SAT-M performance for the women in the two groups of majors. This was accomplished by computing the interaction terms between major group and other variables in the model, and the appropriate terms added to each equation defining the model. The increase in the amount of variance explained by the addition of the interaction terms was then tested for statistical significance for each of the equations. In no case was there a significant increase in the amount of variance explained, indicating that the effects of influential variables in the model would be the same for women in the two groups of quantitative majors.

The causal effects implied in the proposed model were then estimated with ordinary least squares procedures using GEMINI (Wolfle and Ethington, 1985), a FORTRAN program based on the work of Sobel (1982) that computes indirect effects and their standard errors in addition to the usual regression results. Three types of effects were forthcoming; direct, indirect, and total. The direct causal effects are represented by regression coefficients, either standardized (beta weights) or unstandardized (b weights). The indirect causal effects are estimated by the sums of the products of direct effects through intervening variables in the model. These effects represent the influence on the dependent variable that is the results of directly influencing prior causal variables in the model. The total causal effects are simply the sum of the direct and indirect effects.

RESULTS

The direct, indirect, and total effects on undergraduate major and SAT-M performance are given in both standardized and metric form in Table 3. As can be seen, the variables in the model explain 17.9% of the variance in choice of undergraduate major and 58.7% of the variance in SAT-M performance. The explanation of 17.9% of the variance in women's selection of among quantitative majors may appear quite modest. However, it is larger than that found in some studies incorporating many of the same types of measures which examined the influences on women choosing between quantitative and non-quantitative majors. For example, Peng and Jaffe (1979) reported only 6% variance explained and Ethington and Wolfle (1987) reported a slightly higher 9.4%.

Insert Table 3 About Here

Positive direct and indirect effects on the SAT-M performance of the women in this sample intending to major in mathematics-related curricula were found from race, years of mathematics studied in high school, and perceptions of mathematics and science ability. Also, high school rank exerted a positive direct effect and a negative direct effect was seen from perception of leadership ability. Additional positive indirect effects were seen from family income, years of high school science courses, number of advanced science and mathematics courses taken, extracurricular activities, mathematics grades, and science grades. The primary mediating variables for the indirect effects were mathematics and science self-rating and high school rank.

Only two variables in the model, mother's education and undergraduate major group, did not have significant total effects on SAT-M performance, and examination of the total effects underscores the importance of mathematics and science self-rating for the women in this sample. Not only did this self-rating measure have the largest direct and total effects in the model, but it had significant indirect effects and served as the primary mediating variable for the indirect effects of the other variables (see Table 4 for means and standard deviations).

Insert Table 4 About Here

Intended undergraduate major did not have a significant effect on SAT-M performance for the women in this sample (b = 8.6, p = .423). Thus, the approximate 64 point difference in mean SAT-M performance between these two groups (t = 4.47, p < .001) is reduced to 8.6 points when controlling for the effects of the other variables in the model. It appears then that the large residual resulting from the median polish is in part attributable to differences between the two groups of women on the other affective variables in the model.

Affective variables differentiating between the two groups of women are those having significant effects on undergraduate major group. Both parental income and years of science studied in high school had positive direct and indirect effects on undergraduate major. Mathematics and science self-rating again was the most influential variable. This measure had the largest direct effect and served as the mediating variable for the indirect effects noted above as well as the other indirect effects which were seen from father's education and number of advanced courses. All of the effects on undergraduate major, both direct and indirect, were positive which indicates that women with higher values on these variables were more likely to select majors in engineering or the physical sciences than majors in mathematics, statistics, physics, or computer science. It should be noted that each of the variables exhibiting influence on undergraduate major selection had significant direct, indirect, or total effects on SAT-M performance.

DISCUSSION

The results of this study showed that the pattern of differences in quantitative performance measures is the same for groups of intended undergraduate majors as for those students who had completed their undergraduate study. In particular, women intending to major in areas of engineering and the physical sciences exhibit the same atypical performance as that shown by women who did major in these fields. However, the large difference in the mean SAT-M performance found between women intending mathematics, statistics, physics, and computer science majors versus those intending majors in engineering and the physical sciences disappeared when the effects of other variables were controlled for, and these effects were found to be the same for both groups. That is, while women intending to major in engineering or physical sciences have higher values on average on the influential variables, increases on these measures produce comparable increases in SAT-M performance for both groups of women.

Some of the measures that were found in previous studies to differentiate between women in quantitative and non-quantitative fields of study were found here to also differentiate among women within quantitative areas. In particular, taking more science courses in high school, having higher self-ratings relative to mathematics and scientific abilities, and having higher indices of family background not only enhances the likelihood of the selection of a quantitative field of study, but enhances the likelihood of selecting engineering or the physical sciences as a major.

Self-rating relative to others with respect to mathematics and science ability appears to be a primary variable in this model, for not only does it exert strong direct effects on both intended undergraduate major and SAT-M performance, it has indirect effects on SAT-M and is a mediating variable for all other indirect effects in the model. The importance of self-rating found in this study may be related to research that has found that females, even very mathematically-proficient females, are less likely to attribute success in mathematics to ability (e.g., Campbell, Connolly, and Pizzo, 1986; Leder, 1982). Leder (1986) posits that the inappropriate attributions of success could lead to avoidance of mathematics and the development of cognitive, motivational, or emotional deficits. While the self-rating measure used in this study is not attribution, the influence of self-rating in this model emphasizes the importance of mathematically capable women perceiving themselves as having good mathematical and scientific abilities. In terms of relative importance in this model, it is stronger even than years of mathematics studied in its influence on both intended undergraduate major and SAT-M performance.

A recent report by Lockheed, Thorpe, Brooks-Gunn, Casserly, and McAloon (1987) called the middle school years the critical ones for females concerning participation and performance in mathematics and science. One of the factors that was suggested for improving student performance was the providing of opportunities for the development of positive expectations for students' competence in mathematics and science. The results of the present study support this conclusion. Efforts should be made to not only encourage females' enrollment in mathematics and science courses, but to shape positive attitudes toward the study of mathematics and science and females' perceptions of their quantitative abilities. Intervention programs such as Multiplying Options and Subtracting Bias (Fennema, Becker, Wolleat, and Pedro, 1980) could be used with females, beginning in the middle school years, to effect change in attitudes, perceptions, and course-taking patterns.

REFERENCES

Berryman, S. E. (1985, May). Minorities and women in mathematics and science: Who chooses these fields and why? Paper presented at the annual meeting of the American Associa' .n for the Advancement of Science, Los Angeles.

Boli, J., Allen, M. L., & Payne, A. (1985). High-ability women and men in undergraduate mathematics and chemistry courses. American Educational Research Journal, 22, 605-626.

Campbell, J. R., Connolly, C., & Pizzo, J. (1986, April). Self-concepts and attributions of Westinghouse Talent Search Award recipients. Paper presented at the annual meeting of the American Educational Research Association, San Francisco.

Dunteman, G., Wisenbaker, J., & Taylor, M. E. (1979). Race and sex differences in college science program participation. Research Triangle Park, N. C.: Research Triangle Institute.

Ethington, C. A., & Wolfle, L. M. (1986). Sex differences in quantitative and analytical GRE performance: An exploratory study. Research in Higher Education, 25, 55-67.

Ethington, C. A., & Wolfle, L. M. (1987, April). The selection of quantitative undergraduate fields of study: Direct and indirect influences. Paper presented at the annual meeting of the American Educational Research Association, Washington, D. C.

Fennema, E., Becker, A. D., Wolleat, P. L., & Pedro, J. J. (1980). Multiplying options and subtracting bias. Cambridge, MA: Educational Development Corporation.

Leder, G. C. (1982). Learned helplessness in the classroon - a further look. Research in Mathematics Education in Australie, 2, 40-55.

Leder, G. C. (1986, April). Gender linked differences in mathematics learning: Further explorations. Paper presented at the annual meeting of the National Council of Teachers of Mathematics, Washington, D. C.

Lockheed, M., Thorpe, M., Brooks-Gunn, J., Casserly, P., & McAloon A. (1987). Sex & ethnic differences in middle school mathematics, science, and computer science: What do we know? Princeton, N. J.: Educational Testing Service.

Lunneborg, P. W., & Lunneborg, C. E. (1985). Nontraditional and traditional female college graduates: What separates them from the men? Journal of College Student Personnel, 26, 33-36.

Peng, S. S., & Jaffe, J. (1979). Women who enter male-dominated fields of study in higher education. American Educational Research Journal, 16, 285-293.

Sobel, M. (1982). Asymptotic confidence intervals for indirect effects in structural equation models. In S. Leinhardt (Ed.), Sociological methodology 1982. San Francisco: Jossey-Bass.

Steincamp, M. W., & Maehr, M. L. (1984). Gender differences in motivational orientations toward achievement in school science: A quantitative systhesis. American Educational Research Journal, 21, 39-59.

Tukey, J. W. (1977). Exploratory Data Analysis. Reading, Mass: Addison-Wesley.

Ware, N. C., Steckler, N. A., & Leserman, J. (1985). Undergraduate women: Who chooses a science major? Journal of Higher Education, 56, 73-84.

Wolfle, L. M., & Ethington, C. A. (1985). GEMINI: Program for analysis of structural equations with standard errors of indirect effects. Behavior Research Methods, Instruments, & Computers, 17, 581-584.

Table 1

Median Polish of SAT-M Mean Scores, College-bound High School Seniors, 1982-83

	Intended Undergraduate Major							Gender	
	Math	Stat./Phys	Eng	Phys Sci	Bio Sci	Soc Sci	Humanities	Median	Effect
Men	580.42	510.98	533.68	524 04	498 91	461 95	471 33	51C 98	
Women	534.81	469.75	549 46	510 00	451 42	427 95	437 83	469 75	
Total	556.27	496.57	536 69	519 43	468 48	442 10	450 60	496 57	
Men	5.81	3 62	-24 89	-9 98	6 75	0	- 25		19 85
Women	-5 81	-3 62	24 89	9 98	-6 75	0	25		-14 15
Group Effect	58 20	-9 06	42 15	17 60	-24 26	-54 47	-[illegible]4 84	496 57	

Table 2

Operational Definitions of Variables

Variables	Definitions
Race	Coded 1 = nonwhite, 2 = white
Father's education	Highest level of education completed by respondent's father with eight levels ranging from (1) grade school to (8) graduate or professional degree
Mother's education	Highest level of education completed by respondent's mother. Coding same as above.
Income	Combined parental income with 15 levels ranging from (1) less than $3,000 to (15) $50,000 or more.
Yrs. math	Total years of mathematics studied in high school. Coded 0 = none to 5 = more than four.
Yrs. science	Total years of biological and physical sciences studied in high school. Coded 0 = none to 10 = more than 8 years.
Advanced	Variable indicating enrollment in advanced mathematics, biological sciences, or physical sciences courses with values ranging from (0) no advanced courses to (3) advanced courses in each area.
Extracurricular activities	A measure of the degree to which the respondent participated in extracurricular activities. It was created by summing the responses to 3 questions about participation in community or church groups, athletics, and clubs and organizations. Each question had responses ranging from (0) no participation to (4) held five or more major offices.

Math grades	Latest year-end or midyear grade received in mathematics course. Coded (1) failing to (5) excellent (90-100 or A).
Science grades	Average of latest year-end or midyear grade in biological and physical science courses. Coded as above.
Math/science self-concept	Sum of respondent's rating of self relative to others with respect to mathematical, mechanical, and scientific abilities. Each rating ranged from (1) below average to (5) highest 1%. The alpna reliability for this measure was .71.
Leadership self-concept	Sum of respondent's rating of self relative to others with respect to getting along with others, leadership ability, organizing work, sales ability, and spoken expression. Coded as above. The alpha reliability for this measure was .82.
High school rank	Most recent high school rank with six levels ranging from (1) lowest fifth to (6) highest tenth.
Group	Variable representing intended college major with 1 = mathematics, statistics, physics, or computer science and 2 = engineering or physical sciences.
SAT-M	Latest Scholastic Aptitude Test mathematics score.

Table 3
Direct, Indirect, and Total Effects[a]

Independent Variables	Group Direct	Group Indirect	Group Total	SAT-M Direct	SAT-M Indirect	SAT-M Total
Race	-.095 (- 100)	025 (.027)	-.070 (- 073)	186* (51 648)	.117* (32.568)	303* (84.216)
Father's education	045 (010)	059** (014)	.104 (024)	087 (5.269)	.071 (4 301)	.158** (9 570)
Mother's education	-.050 (- 013)	031 (.008)	- 019 (- 005)	017 (1 099)	.048 (3 145)	065 (4 244)
Income	158** (018)	063** (007)	.221* (025)	.083 (2.475)	.106* (3.157)	.189* (5.632)
Yrs. Math	002 (.001)	009 (.005)	011 (006)	.146* (22 350)	121* (18 541)	267* (40 891)
Yrs. Science	167* (072)	041** (018)	.208* (090)	022 (2 457)	.076* (8 627)	098** (11 084)
Advanced courses	051 (.031)	051* (031)	102 (.062)	033 (5.399)	.095* (15 247)	.128* (20 646)
Extracurricular activites	028 (.005)	034 (.007)	.062 (012)	082 (4.135)	.072** (3.641)	154* (7.776)
Math grades	- 090 (-.050)	056 (031)	- 034 (- 019)	.083 (12 142)	.107* (15 607)	190* (27.749)
Science grades	051 (.034)	029 (.019)	.080 (.053)	080 (14 069)	.133* (23 184)	213* (37.253)
Math/science	268* (.049)	- 010 (-.002)	.258* (.047)	292* (14.125)	037** (1.802)	329* (15 927)
Leadership self-concept	-.001 (- 000)	- 002 (- 000)	- 003 (-.000)	- 148* (-4 735)	.005 (.154)	-.143* (-4.581)
High school rank	- 055 (- 022)		- 055 (- 022)	167* (17 264)	- 002 (- 187)	165* (17 077)
Group				033 (8 609)		033 (3 609)
R^2	179			587		

[a]Metric effects are given in parentheses
*p<.01; ** p< 05

Table 4

Means and Standard Deviations for Variables in Causal Model

	Group 1*		Group 2		Combined	
Variables	Mean	St. Dev.	Mean	St. Dev.	Mean	St. Dev.
Race	1.740	.440	1.768	.424	1.748	.435
Father's education	4.598	2.026	5.442	1.767	4.854	1.987
Mother's education	4.215	1.831	4.758	1.773	4.379	1.828
Income	8.438	3.958	10.579	3.932	9.086	4.065
Years of mathematics	3.836	.846	4.084	.613	3.911	.790
Years of science	3.114	.977	3.768	1.106	3.312	1.060
Advanced courses	.521	.693	.779	.840	.599	.749
Extracurricular	5.014	2.270	5.800	2.567	5.252	2.387
Math grades	4.192	.840	4.379	.788	4.248	.828
Science grades	4.180	.704	4.474	.612	4.269	.690
Math/science self-rating	8.312	2.384	10.126	2.289	8.860	2.496
Leadership self-concept	15.671	3.603	17.053	4.012	16.089	3.779
High school rank	4.671	1.197	5.053	1.076	4.787	1.173
SAT-M	478.402	119.524	542.737	111.855	497.866	120.763

* Group 1, n = 219; Group 2, n = 95