# 7 An Accelerated Mathematics Program for Girls: A Longitudinal Evaluation

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## Abstract

*Moderately gifted seventh-grade girls were invited to attend a fast-paced summer class in algebra I that provided for the special needs of girls. In addition to emphasizing algebra, the program catered to the social needs of girls, provided interaction with female role models who had careers in the mathematical sciences, and encouraged the girls to study a number of years of mathematics. Two control groups, one of boys and one of girls, similar in ability and parental variables, were chosen. Seven years after the class, its long-term effects were investigated by analyzing the group's responses to two questionnaires. Girls who completed the program successfully (i.e., were placed in algebra II the following fall) were more accelerated and took more mathematics courses in high school and college. Those were, however, the only major differences between the girls who constituted the experimental group and the two control groups. No such effects were found for the girls who attended the class but were not successful in it. There were no major differences in educational experiences, educational aspirations, or career goals. Girls perceived the lack of role models as the greatest barrier women face when contemplating a career in mathematics or science. Boys, however, felt that for women the difficulty of combining career and family responsibilities was the greatest barrier. It is concluded that in order for girls to receive the long-term benefits of an early intervention program, they must complete the program successfully and also be mathematically abler than most of these girls were.*

Far fewer women than men pursue careers in mathematical and scientific fields (Dearman & Plisko 1979, pp. 232–33). It has been suggested that many gifted girls limit their opportunities for careers in mathematics and science by not electing to take advanced mathematics courses in high school (Sells 1980). Among college-bound students, more boys than girls take four or more years of high-school mathematics, and far more boys than girls take the College Board's Advancement Placement Program courses and examinations in calculus (CEEB 1975). Therefore, it would seem that efforts to increase the number of women in scientific career areas might begin by developing strategies to encourage high-ability girls to take upper-level mathematics courses in high school.

One way to increase female enrollment in advanced mathematics classes would be to attempt to influence young girls' attitudes about the importance of taking such courses for their future careers. Another more direct strategy would be to have girls who reason well mathematically begin the sequence of advanced mathematics courses at an earlier age.

The Study of Mathematically Precocious Youth is a unique program in which both counseling and accelerated mathematics courses are offered to mathematically highly able boys and girls as early as grade seven. Results of SMPY's first accelerated mathematics class, begun for both boys and girls in the summer of 1972, suggested that attention to the social interests of girls was necessary to attract them to and retain them in an accelerated mathematics program (Fox 1976). Therefore, in the summer of 1973, an experimental mathematics program was conducted for mathematically gifted end-of-the-year seventh-grade girls (Fox 1976). The class met two days each week for approximately two hours from May through July and covered a standard algebra I curriculum. It was hoped that a positive experience in mathematics at the junior-high-school level, when mathematics becomes more abstract, along with the opportunity to accelerate one year in mathematics, would increase the likelihood that the girls would take advanced mathematics courses in high school.

The class was designed to provide social stimulation in several ways. The teacher, a woman, was assisted by two female undergraduate mathematics majors. The structure of the class was informal. Both individualized and small group instruction were utilized. Furthermore, cooperative rather than competitive activities were stressed, and some traditional word problems were rewritten to make them more socially appealing. The classroom work was supplemented by a series of speakers, both male and female, who met with the girls to talk about their careers in mathematics and science (Fox 1976).

Students were selected for the program on the basis of performance on the mathematics subtest of the College Board's Scholastic Aptitude Test-

Mathematics in either the mathematics or the verbal contests conducted by SMPY and the Study of Verbally Gifted Youth (SVGY), respectively, at The Johns Hopkins University in January or February of 1973. Thirty-two seventh-grade girls enrolled in public schools in Baltimore County, Maryland, who had scored at least 370 on the SAT-M as seventh-graders were invited to take part in the class. Two additional girls were invited on the basis of referral and subsequent testing. Twenty-six of these girls (77 percent) enrolled in the course. This was considerably better than the enrollment rates of 58 percent and 26 percent, respectively, for the 1972 and 1973 summer, mixed-sex accelerated classes conducted by SMPY (Fox 1974; George & Denham 1976).[1] Thus the emphasis on social factors was successful in recruiting girls for such an accelerated program.

The mathematics course for the experimental girls was not totally successful. Of the twenty-six girls who enrolled for the course, only eighteen actually attended the classes on a fairly regular basis and completed the course. The completion rate for the course was not significantly higher than the completion rate for girls in the two other accelerated classes, which were coeducational (Fox 1974; George & Denham 1976).

The letters to the experimental girls, their parents, and their schools before the start of the program had explained that girls who were successful in learning first-year algebra during the summer would be allowed to take an algebra II course in the fall. By the end of the summer, eighteen experimental girls were considered to be ready to take the algebra II course in the eighth grade. They had met Baltimore County public school officials' criterion for success—the sixty-fifth percentile on ninth-grade national norms on Form A of the Algebra I Test of the Cooperative Mathematics Series.

During the late summer and early fall, however, nine girls found their principal or guidance counselor reluctant to place them in algebra II. Three of these girls were quickly persuaded by their schools to repeat algebra I, and one girl (in a private school) was placed on one-month probation in algebra II. The remaining fourteen girls were officially enrolled for algebra II by the third week of school.

Negative reactions from the schools appeared to have had a detrimental effect upon the progress of quite a few of the girls in their mathematics classes. Three girls gave in to the wishes of their schools and repeated algebra I. Of the fifteen girls who began algebra II in the fall, two were transferred into algebra I by the end of the first six weeks of school. One girl was put back because she missed two weeks of school and earned a failing grade for the first six weeks. She had been placed in algebra II but because of scheduling problems she could meet with the class for only three of the five class sessions. The second girl who was transferred to algebra I after the first six weeks was the one on probation in the private school.

At the end of the first semester two more girls were put back into algebra I. These girls attended the same school. They were the two girls who had not met the sixty-fifth-percentile criterion on the algebra test at the end of the program but were retested before school began and allowed to enter algebra II. Both of these girls met with unfavorable reactions from their teacher or guidance counselor concerning their acceleration.

Thus, of eighteen girls who completed the program, only eleven (61 percent) were able to accelerate their mathematics progress in school. This is 42 percent of the twenty-six girls initially enrolled for the course. Of the fifteen girls who were initially placed in algebra II, eleven (73 percent) succeeded in staying in algebra II; eight of these girls (53 percent) made excellent progress. Of the eleven girls who completed algebra II, four earned final grades of *A*, five earned *B*, one *C*, and one *D*. Ten of these girls took geometry the following year (1974–75), and nine of them reported grades of *A* for the first grading period. The tenth girl did not report her grade.

Two control groups had been formed, one of girls and one of boys (Fox 1976). For each experimental girl enrolled in the course, a control boy and a control girl had been selected from among other seventh-grade participants in the 1973 contests. These students were seventh-graders enrolled in schools in all areas of Maryland except Baltimore County. The control students were matched with the experimental subjects on the basis of scores on the mathematical and verbal subtests of SAT, education and occupation of father, and education of mother.

Although the matching was not perfect, the general pattern was to match within plus or minus twenty points on the SAT-M and the SAT-V while controlling for the educational and occupational levels of parents. The details for the matching variables for the three groups are reported elsewhere (Fox 1976) and are summarized in table 7.1.

## The 1980 Follow-Up Study

In the spring of 1980 each student in the experimental and control groups was sent a brief questionnaire to determine his or her educational status and career plans (Appendix 7.1). This was the time at which most of the students were completing their second year of college. Most of these students had also been included in a follow-up survey of 1973 talent-search participants in December, 1978, the fall after which they would normally have become high-school graduates. Students who had not responded to this questionnaire then were requested to complete it in 1980. (Details of the follow-up surveys are contained in Benbow, chapter 2 of this volume.) Short questionnaires were received from all students, and only one experimental girl never completed the follow-up survey. Data from the two

TABLE 7.1. Mean Scores on SAT-M and SAT-V in the 1973 Talent Search and in High School and the Educational Level of Parents (by Group)

| Group | $N$ | Mean[a] Talent Search SAT-M | Mean[a] Talent Search SAT-V | Mean[a, b] High School SAT-M | Mean[a, b] High School SAT-V | Mean Educational Level[c] Mother | Mean Educational Level[c] Father |
|---|---|---|---|---|---|---|---|
| Experimental girls | 26 | 436 | 399 | 631 | 595 | 2.9 | 3.3 |
| Control girls | 26 | 433 | 390 | 634 | 594 | 2.9 | 3.7 |
| Control boys | 26 | 443 | 393 | 658 | 564 | 2.7 | 3.5 |

[a] The mean scores of college-bound high-school seniors on the SAT-M are 492 (males) and 443 (females); on the SAT-V they are 430 (males) and 418 (females). (Admissions Testing Program of the College Board, *National Report: College-Bound Seniors* [Princeton, N.J.: Educational Testing Service, 1981].)

[b] These scores were reported by the students on their questionnaires. Twenty experimental girls, twenty-three control girls, and twenty-five control boys reported taking the test.

[c] The scale was as follows: 1 = less than high school; 2 = high-school diploma; 3 = some college; 4 = bachelor's degree; 5 = graduate study beyond the bachelor's degree.

surveys include detailed information on course-taking in high school as well as information about the students' attitudes toward acceleration and mathematics. The educational experiences and career goals of the three groups are summarized in the following sections.

**SAT Scores in High School.** Most of the students in the three groups took the Scholastic Aptitude Test sometime during their junior or senior year of high school. In the 1978 questionnaire they reported their scores on the examination as well as the date they took it. Since the times the examination was taken varied by six months or less, the mean scores for the groups were determined and are shown in table 7.1. An analysis of variance for matched triads was not significant. Thus the groups were very similar in high school on measures of mathematical and verbal aptitude and were superior to a national sample of college-bound seniors, even though the slightly higher SAT-M mean for boys in 1973 had been significant. A table of intercorrelations among the groups is included in Appendix 7.2. It can be seen there that talent-search and high-school SATs correlate highly. Moreover, the *r*s are consistent across the groups. For example, talent-search SAT-M scores of the experimental girls correlate with high-school SAT-M scores of the control girls to the same degree as the talent-search SAT-M scores of the control girls do (i.e., .74 for the experimental girls' talent-search SAT-M with control girls' high-school SAT-M and .73 for control girls' talent-search SAT-M with control girls' high-school SAT-M).

At the time of the talent search the correlation of SAT-M and SAT-V scores of experimental girls and the control boys and girls was much higher (i.e., $r \geq .90$). In high school the matching had become less tight, as would be expected, yet it was still significant. The lowering of the $r$ can have resulted from different high-school experiences. Also, the date of taking the SAT was not uniform, which would lower the *r*. Nevertheless, in high school the matching was significant.

**Acceleration.** As noted earlier, at the end of the 1973–74 school year following the summer of 1973 class, only eleven of the experimental girls were accelerated in their mathematics course-taking. None of the control boys or control girls was accelerated in mathematics at that time. By the end of the ninth and tenth grades the eleven experimental girls were still accelerated, and some of the control girls and boys had begun to accelerate.

An analysis of variance was performed using acceleration in mathematics at the end of the ninth grade as the dependent variable. The independent variables were group belonged to and triad, ranked in order of increasing ability on SAT-M and SAT-V, belonged to. The ANOVA was significant ($F = 4.2$, $p < .05$). By the end of the tenth grade the differences were almost significant ($F = 3.1$, $p = .07$). The control boys, but not girls, had caught up with the experimental girls. The degree of acceleration is shown in table 7.2.

A major reason for attempting the acceleration of the experimental girls was to increase the likelihood of their taking a calculus course in high school. Seven experimental girls did complete the four-year precalculus sequence in the tenth grade but chose another elective instead of calculus the next year. The percentage of students who took calculus in high school within each group is also shown in table 7.2. More boys than girls of either group took a calculus course in high school. As matched pairs, however, the difference was not statistically significant by an ANOVA with two independent variables, membership in group and triad. Triad membership was ranked in order of increasing ability on SAT-M and SAT-V. The $F$ equalled 2.6 for the group effect, which was not significant. The effect of triad and the interaction term were also not significant. Essentially equal proportions of experimental and control girls (about 35 percent each) took calculus, compared to 62 percent of the boys. The percentages of boys and girls in this study who took calculus are similar to the percentages of boys and girls, respectively, included in the high-school follow-up of students from the first three talent searches who took calculus (see Benbow, chapter 2 of this volume). Overall, the experimental girls and control boys took more years of high-school mathematics than did the control girls (see table 7.2). Again, the difference in mathematics course-taking between the three groups was not significant by an ANOVA using group and triad membership as independent variables. The $F$ for group membership equalled 1.2.

The degree of total acceleration for students in each group can be seen in table 7.3. Although there were no statistically significant differences among the groups, there were more control girls who were accelerated by one or two years. Three of the control girls were accelerated prior to the 1973 talent search, and two skipped eighth grade immediately following

TABLE 7.2. Students Accelerated in Mathematics in Grades 9 and 10, Taking High-School Calculus, and Taking More than 5 Years of High-School Mathematics (by Group, in Percentages)

| Group | *N* | Took Accelerated Mathematics: Grade 9 | Took Accelerated Mathematics: Grade 10 | Took High-School Calculus[a] | Took More than Five Years of Mathematics[a, b] |
|---|---|---|---|---|---|
| Experimental girls | 26 | 42 | 42 | 36 | 32[c] |
| Control girls | 26 | 4 | 8 | 35 | 12 |
| Control boys | 26 | 19 | 31 | 62 | 19 |

[a] The differences between the groups were not significant by an ANOVA.
[b] Data for one experimental girl were incomplete.
[c] This includes the algebra I that some completed during the summer of 1973.

TABLE 7.3. Degree of Educational Acceleration (by Group, in Percentages)

| Group | *N* | Degree of Acceleration[a, b] 0 | 1 | 2 | 3 |
|---|---|---|---|---|---|
| Experimental girls | 26 | 46 | 31 | 23 | 0 |
| Control girls | 26 | 38 | 27 | 35 | 0 |
| Control boys | 26 | 38 | 38 | 23 | 0 |

[a] Degree of acceleration was coded as follows: 0 = no acceleration; 1 = some acceleration but totalling less than one year; 2 = moderate acceleration totalling 1 year or more but less than 3; 3 = acceleration totalling 3 years or more.
[b] Differences between the groups were not significant by an ANOVA.

the talent search. Only one experimental girl and two control boys had skipped kindergarten or elementary grades prior to the talent search. Acceleration in these two groups had resulted primarily from skipping the senior year of high school.

Students were asked how they viewed their acceleration. The majority of accelerated students within each group now wished they had accelerated more. One experimental girl wished she had not accelerated at all, and two control girls wished they had accelerated less. Of those who had not accelerated, most seemed to feel they had made the right choice.

Students in each group were asked if they felt they had made use of all available educational opportunities. The majority of control girls and control boys felt they had done as well as possible. More experimental girls than control group boys or girls, however, felt that they had not made good use of their opportunities. An analysis of variance on the dependent variable (i.e., rated use of educational opportunities) by matched groups, however, was not significant.

**The College Experience.** In the spring of 1980 the majority of students in each group were still enrolled in college as full-time students. One experimental girl and one control girl had never enrolled and were working. A few students in each group were enrolled and were working. Some in each

TABLE 7.4. College Attendance and Intellectualism and Status Scores of Colleges Attended (by Group)

| Group | $N$ | Full-Time Student (%) | Part-Time Student (%) | Not Presently Enrolled (%) |
|---|---|---|---|---|
| Experimental girls | 26 | 77 | 4 | 15 |
| Control girls | 26 | 85 | 4 | 8 |
| Control boys | 26 | 77 | 12 | 12 |

[a]Intellectualism and status scores, derived from the scale by A. W. Astin (*Who Goes Where to College?* [Chicago: Science Research Associates, 1965], pp. 57–84), are reported as T-scores for most four-year colleges. Scores reported here were found from twenty,

group were enrolled part time or had dropped out of college. The details of college attendance can be seen in table 7.4. No significant differences were found among the three groups.

The choice of college ranged from local junior colleges to prestigious universities. An analysis of variance of the intellectualism and status ratings of the institutions (Astin 1965), respectively, showed no significant differences among the three groups, as can be seen in table 7.4. The trend, however, was for the males and then the control females to attend the academically more prestigious schools. A more personal analysis of the actual list of institutions suggested that control girls went farther from home to college while the experimental girls and control boys chose more local colleges. Six control boys, one control girl, and one experimental girl attended The Johns Hopkins University. The experimental girl, an evening college student in engineering, left Drexel University for reasons of a family financial crisis. The control girl who enrolled at Hopkins is the daughter of a faculty member. Thus the appeal of Johns Hopkins, due perhaps at least partly to participating in the talent search or experimental class, seems to have been weak for the girls but rather strong for boys. Overall the students seemed happy with their college choices; they did not differ significantly in their rated liking of college. Only two boys and one control girl reported that they disliked college, and no experimental girls did so.

A distribution of students by college major can be seen in table 7.5. For purposes of comparison, five broad categories were formed. The first was mathematics, in which engineering and economics were included. The second was science, which includes those indicating premedical preparation. The third, fourth, and fifth were social sciences, humanities, and business or law. Analysis of the paired distribution of those enrolled in mathematical or science majors versus those in other areas was not significant. The trend, however, was for more boys than girls in either group to major in a mathematical or scientific area. Slightly more experimental girls were in mathematical majors than science areas, but control girls were divided

| Never Enrolled (%) | Intellectualism Score[a] Mean | Intellectualism Score[a] Standard Deviation | Status Score[a] Mean | Status Score[a] Standard Deviation |
|---|---|---|---|---|
| 4 | 53 | 14 | 55 | 10 |
| 4 | 56 | 14 | 55 | 10 |
| 0 | 61 | 12 | 58 | 12 |

twenty-one, and twenty-four colleges attended by the experimental girls, the control girls, and the control boys, respectively.

evenly between mathematical and scientific majors. Studies of large samples of college students typically find a higher attrition rate in mathematical majors for women than men (Melone 1980). In the present study, however, only one person in each group had already changed his or her major away from mathematics.

On the basis of the similarity in college majors, one might expect there to be little difference, or a slight difference in favor of the control boys, among the three groups in the mathematics courses taken in college. It is interesting to see that in terms of the number of semesters of mathematics studied, control boys and experimental girls were identical. As can be seen in table 7.6, they took more mathematics courses than did control girls. An analysis of variance for matched groups, however, was not significant.

With regard to attitudes held toward mathematics, no differences between the groups were detected. While in high school the control girls

TABLE 7.5. College Majors and Career Plans of Students (by Group, in Percentages)

| Group | *N* | M | S | SS | H | B/L | N |
|---|---|---|---|---|---|---|---|
| | | | | College Major | | | |
| Experimental girls | 22 | 32 | 14 | 18 | 18 | 18 | 0 |
| Control girls | 24 | 21 | 21 | 17 | 21 | 21 | 0 |
| Control boys | 24 | 42 | 21 | 13 | 17 | 8 | 0 |
| | | | | Career Plan | | | |
| Experimental girls | 26 | 19 | 8 | 4 | 12 | 27 | 30 |
| Control girls | 26 | 15 | 23 | 19 | 15 | 19 | 9 |
| Control boys | 26 | 31 | 15 | 4 | 23 | 15 | 12 |

NOTE:
M = Mathematics, engineering, and economics
S = science
SS = social sciences
H = humanities
B/L = business or law
N = no response or undecided

TABLE 7.6. Mean College Semesters of Mathematics and Grade Point Average in the Mathematics Courses for Those Enrolled Full Time (by Group)

| Group | *N* | Math Semesters | *N* | Grade Point Average |
|---|---|---|---|---|
| Experimental girls | 20 | 3.25 | 17 | 3.24 |
| Control girls | 22 | 2.64 | 19 | 3.38 |
| Control boys | 20 | 3.20 | 16 | 3.34 |

rated their liking for mathematics more positively than the experimental girls, but the differences were not statistically significant. Moreover, the three groups, while in high school, did not differ in the perceptions of the usefulness of mathematics for their future careers.

**Educational Aspirations and Career Goals.** The educational aspirations of students in all three groups are high, as one might expect given the fact that as seventh-graders they were all in the top 3 percent of their age group with respect to mathematical ability. There were no differences among the three groups, as can be seen in table 7.7. The mean of the educational aspirations for all three groups was somewhat more than a master's degree.

The distribution of students by category of career goal, by group, can be seen in table 7.5. No significant differences emerge when career interest in mathematical/scientific/medical careers are compared with all other career interests, and no clear trends appear. Experimental girls are oriented toward careers in business, law, or mathematics/science, with only a few interested in the social sciences or humanities. In contrast, the control girls are more evenly distributed among the options. Finally, control boys are very strongly oriented toward the careers in mathematics and science, followed by interest in business or law. The boys show less interest in careers in the humanities and social sciences than do the control girls but about the same degree of interest as the experimental girls.

## PERCEIVED BARRIERS TO MATHEMATICAL OR SCIENTIFIC CAREERS

On the 1980 questionnaire each student was asked to rate eight possible barriers to careers in mathematics or science for women on a scale of zero to two. Zero was "no problem"; one was a "minor problem"; and two was a "serious problem." The results can be seen in table 7.8. There were no statistically significant differences among the three groups in their ratings of six of the eight factors.

Girls in both groups viewed the lack of appropriate role models and lack of information about careers in mathematics as more serious problems than did the boys. These differences in ratings were significant. Boys rated the "perception of women majoring in engineering and science as

TABLE 7.7. Highest Level of Educational Aspiration of Students (by Group)

| Group | *N* | High School | Some College or Vocational Training | B.S. | M.A. | Ph.D., etc. | Post-doctoral Study | Mean[a] | Standard Deviation |
|---|---|---|---|---|---|---|---|---|---|
| Experimental girls | 25 | 0 | 8 | 4 | 56 | 28 | 4 | 4.2 | 0.9 |
| Control girls | 26 | 4 | 0 | 23 | 35 | 27 | 12 | 4.2 | 1.2 |
| Control boys | 25 | 0 | 4 | 20 | 36 | 32 | 8 | 4.2 | 1.0 |

[b]Educational aspiration was coded as follows: 1 = high school; 2 = some college; 3 = bachelor's degree; 4 = master's degree; 5 = doctorate degree; 6 = postdoctoral study.

unfeminine" as a more serious problem than did the girls, but the difference was not statistically significant.

A rank ordering from the greatest to the least problem, based on mean ratings, is similar for the two groups of girls. The lack of role models was viewed as the greatest problem; the perception of scientists as cold and impersonal was the least. Boys, however, viewed the problem of combining a career and family responsibilities as the most serious problem for women and the long years of preparation required as the least serious problem. It would seem that the boys did not perceive these possible barriers in the same way the girls did.

Since the lack of encouragement and support for mathematical and scientific careers for women was viewed as a problem by all three groups, it is interesting to look at how much encouragement and support the students in each group felt they had received. We had expected that the boys would have received the most. There were no statistically significant differences, however, among the three groups in their responses to a Likert-scale rating of encouragement and support received for their interest in and study of mathematics (see table 7.9). All three groups reported receiving "some," but not "much," encouragement.

On an open-ended question as to why they had or had not personally chosen to pursue a career in mathematics or science, the responses varied widely. For those who were interested in a mathematical or scientific career, the most frequent response was that they enjoyed the field. This was the most frequent response of experimental girls and control boys in particular. Control girls were more likely to mention the possibility of helping people as a major reason. This perhaps is related to the somewhat higher percentage of control girls in the medical science majors. The factor of having the ability was mentioned by one experimental girl and one control boy, but no control girls mentioned this. Only one experimental girl

TABLE 7.8. Rated Importance of Possible Factors Preventing Women from Pursuing Careers in Mathematics, Science, and Engineering (by Group)

| Group | *N* | No Problem | Minor Problem | Serious Problem | Mean[a] | Standard Deviation |
|---|---|---|---|---|---|---|
| | | Long Years of Formal Preparation | | | | |
| Experimental girls | 26 | 10 | 12 | 4 | 0.8 | 0.7 |
| Control girls | 26 | 11 | 11 | 4 | 0.7 | 0.7 |
| Control boys | 26 | 16 | 8 | 2 | 0.5 | 0.6 |
| | | Conflicts in Combining Career and Family | | | | |
| Experimental girls | 26 | 4 | 13 | 9 | 1.2 | 0.7 |
| Control girls | 26 | 2 | 17 | 7 | 1.2 | 0.6 |
| Control boys | 26 | 4 | 14 | 8 | 1.2 | 0.7 |
| | | Perception of Women Majoring in Engineering and Science as Unfeminine | | | | |
| Experimental girls | 26 | 15 | 9 | 3 | 0.5 | 0.6 |
| Control girls | 26 | 12 | 11 | 3 | 0.7 | 0.7 |
| Control boys | 26 | 9 | 11 | 6 | 0.9 | 0.8 |
| | | Lack of Encouragement | | | | |
| Experimental girls | 26 | 5 | 13 | 8 | 1.1 | 0.1 |
| Control girls | 26 | 9 | 9 | 8 | 1.0 | 0.8 |
| Control boys | 26 | 9 | 8 | 9 | 1.0 | 0.8 |
| | | Perception of Science and Math Work as Being Too Difficult | | | | |
| Experimental girls | 26 | 6 | 10 | 10 | 1.2 | 0.9 |
| Control girls | 26 | 12 | 8 | 6 | 0.8 | 0.8 |
| Control boys | 26 | 14 | 7 | 5 | 0.7 | 0.8 |
| | | Lack of Information about Careers in Science and Math | | | | |
| Experimental girls | 26 | 3 | 11 | 12 | 1.3 | 0.7 |
| Control girls | 25 | 3 | 13 | 9 | 1.2 | 0.7 |
| Control boys | 26 | 8 | 16 | 2 | 0.8 | 0.6 |
| | | Lack of Appropriate Role Models | | | | |
| Experimental girls | 26 | 1 | 13 | 12 | 1.4 | 0.6 |
| Control girls | 25 | 1 | 13 | 11 | 1.4 | 0.6 |
| Control boys | 26 | 5 | 16 | 5 | 1.0 | 0.6 |
| | | Perception of Scientists as Cold and Impersonal | | | | |
| Experimental girls | 26 | 19 | 4 | 3 | 0.4 | 0.7 |
| Control girls | 26 | 13 | 10 | 3 | 0.6 | 0.7 |
| Control boys | 25 | 12 | 12 | 1 | 0.6 | 0.6 |

[a] Responses were coded as follows: 0 = no problem; 1 = minor problem; 2 = serious problem.

TABLE 7.9. Encouragement and Support Received by Students for Interest in and Study of Mathematics (by Group)

| Group | N | Degree of Support[a] (%) | | | | | Mean of Support[a] | Standard Deviation |
|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | | |
| Experimental girls | 24 | 4 | 0 | 45 | 29 | 21 | 3.6 | 1.0 |
| Control girls | 24 | 0 | 0 | 54 | 25 | 21 | 3.7 | 0.8 |
| Control boys | 26 | 0 | 0 | 38 | 42 | 21 | 3.8 | 0.7 |

[a] Degree of support was coded as follows: 1 = much discouragement; 2 = some discouragement; 3 = neither support nor discouragement; 4 = some support; 5 = much support.

attributed her interest in a mathematical career to the fact that she had become accelerated in the study of mathematics. One control girl, but no experimental girls or control boys, cited direct encouragement from a significant other (in this case, the parents) as important.

Those who chose careers in other areas were often vague about their reasons for not choosing mathematics, citing only "other interest." Three experimental girls cited the difficulty of mathematics as a deterrent, but no others did so. On the ratings of barriers and reasons for not pursuing careers in mathematics or science, the experimental girls had rated difficulty as a more serious problem than had the other students.

If difficulty of science and mathematics majors deterred our students from entering them, we would expect that our boys would rate their mathematical ability as superior to that of the girls since more boys than girls pursued these majors. When students were asked to rate their mathematical ability relative to that of their high-school peers, however, the three groups did not differ significantly. Nineteen experimental girls, twenty-one control girls, and twenty-two control boys rated themselves as superior. It is of interest to note here that the students in each group had been initially matched on mathematical and verbal ability.

## TREATMENT EFFECTS

When the total group of experimental girls was compared with the control groups on various outcome measures, such as acceleration, course-taking up through college, and college majors, there was only one statistically significant difference. The experimental girls were more accelerated than the control girls in their mathematics course-taking at the end of the ninth grade.

Not all of the experimental girls, however, completed the summer program, and some who did finish the summer course were not able to accelerate their course-taking in high school the following year. Therefore, it seemed desirable to look within the experimental group for effects of differential treatment. Three subgroups of the experimental girls were studied, and their progress relative to that of their matched counterparts was evaluated.

**Subgroup A.** The eleven girls who completed the summer program and completed an algebra II class during the eighth grade had the full benefit of the program. They continued to be accelerated in their mathematics course-taking in the ninth and tenth grades. Six of these students took calculus in the eleventh grade. Three others took college algebra in the eleventh grade and calculus in the twelfth grade. The eleven girls averaged 5.5 years of mathematics courses in high school.

Two girls never took high-school calculus. They were also the only two of the eleven who had not continued to attend college full time. One, a part-time student at the Peabody Institute of The Johns Hopkins University, majored in dance. The other, also at the Peabody Institute, dropped out of the music program.

Of the nine girls who were full-time college students in the spring of 1980, three majored in engineering, two in mathematics, one in business, one in English, and one in biology. One had an undeclared major but had previously been a physics major. She was contemplating a career in nursing. Considering the strong interest in mathematics and related areas, it is not surprising that this group of nine students took an average of 3.6 semesters of college mathematics courses in their first two years of college.

Of the eleven matched control girls, only two accelerated their mathematics course-taking in high school, but seven took a calculus course (compared to nine for the experimental girls). They averaged only 4.6 years of high-school mathematics, however. Nine of the eleven were enrolled full time in college and had averaged only 2.5 semesters of college mathematics. Two were majoring in engineering, two in science, two in business, two in the social sciences, and one in the humanities.

Of the eleven matched control boys, two had accelerated their course-taking and six took a calculus course in high school. They averaged 4.5 years of high-school mathematics. All eleven were enrolled full time in college and averaged 2.5 semesters of college mathematics. Seven majored in engineering, science, accounting, or economics. Three were social science majors and one was a fine arts major.

In summary, for these eleven matched triads, the only differences found were in favor of the experimental girls. The amount of mathematics studied by them in high school or college was greater. These data are summarized in table 7.10.

**Subgroup B.** This group consists of the seven girls who completed the summer course but who either did not enter or did not remain in an algebra II class in the eighth grade. They did not later accelerate their course-taking in mathematics, nor did any of them take a high-school calculus course. The average number of years of high-school mathematics studied by the group was four.

TABLE 7.10. Mathematics Course-Taking in High School and College and College Major (by Subgroups within Groups)

| Subgroups[a] | Groups | N | Mean Number of Years of Mathematics in High School | Percentage Taking Calculus in High School | Percentage Enrolled in College Full-Time in 1980 | Mean Number of Semesters of Mathematics in College[b] | Percentage Majoring in Mathematics/ Science Field[b] |
|---|---|---|---|---|---|---|---|
| | Experimental girls | 11 | 5.5 | 82 | 82 | 3.6 | 67 |
| A | Control girls | 11 | 4.6 | 64 | 82 | 2.5 | 56 |
| | Control boys | 11 | 4.5 | 55 | 100 | 2.5 | 63 |
| | Experimental girls | 6 | 4.0 | 0 | 83 | 1.4 | 40 |
| B | Control girls | 7 | 4.2 | 0 | 100 | 1.6 | 29 |
| | Control boys | 7 | 4.2 | 29 | 43 | 2.7 | 29 |
| | Experimental girls | 8 | 4.0 | 0 | 75 | 1.8 | 17 |
| C | Control girls | 8 | 3.8 | 25 | 75 | 2.3 | 33 |
| | Control boys | 8 | 5.8 | 100 | 75 | 2.5 | 67 |

[a] Subgroups are composed as follows: A = experimental girls who completed algebra II in the eighth grade and their matched controls; B = experimental girls who did not enroll in or complete algebra II in the eighth grade and their matched controls; C = experimental girls who did not complete the program and their matched controls.
[b] Number of cases is those still enrolled full time in college at the end of their second year of college.

Of the seven girls, five were full-time college students in the spring of 1980. One had never enrolled, and one had dropped from a major in special education. The majors of those in college were accounting, business administration, political science, dental hygiene, and theater. The business administration major was interested in a career with a mathematical or statistical emphasis and had taken 3 semesters of college mathematics; the other four had each taken only 1 semester of mathematics in their first two years of college. (The average for the group was 1.4 semesters.)

In comparison, none of the seven matched control girls had accelerated her study of mathematics, and none took calculus in high school. Thus they were similar to their experimental counterparts in mathematics course-taking in high school and college. All were full-time college students but only two majored in a science area. With respect to the seven matched control boys, two of them had accelerated their course-taking in the ninth or tenth grade and had taken high-school calculus. The seven boys averaged 4.2 years of high-school mathematics. Only three of the seven were full-time college students. One was majoring in computer science, one in engineering, and one in business.

The differences among these triads were small. They can be seen in table 7.10.

**Subgroup C.** Eight young women did not complete the summer algebra program and subsequently never became accelerated in their mathematics programs in school. Like the members of group B, they averaged four years of high-school mathematics, and not one of them took calculus in high school.

Six of the eight in this group were full-time college students in the spring of 1980. Three students had a business or economics major; one majored in psychology and education, another in political science, and one in horticulture. During the first two years of college a business major took 4 semesters of college mathematics, the horticulture major 1, and the political science major did not take any. The remaining three students took 2 semesters. For the group the overall average was 1.8 semesters.

None of the control girls who were matched with the eight program drop-outs had accelerated her mathematics progress, either, but two of them had taken high-school calculus. This group averaged 3.8 years of high-school mathematics. Two were pursuing college majors in mathematics, two in the social sciences, one in English, and one in nursing.

Four of the matched control boys had accelerated their study of mathematics in high school. Moreover, all eight took calculus in high school. These boys averaged 5.8 years of high-school mathematics. Six were full-time students in college and averaged 2.5 semesters of college mathematics. Four of the six were majoring in a mathematical or scientific career, and two were in the social sciences.

Thus it is within this triad that large sex differences emerge. The boys were more accelerated in mathematics in high school. They also took more courses, especially calculus. In college, however, the boys took only slightly more mathematics than the girls, even though more of these boys majored in a mathematics-related area. These data are also summarized in table 7.10.

Clearly, the nature of the treatment was important. It appears that at the time the achievement of the experimental females in mathematics and science was only enhanced if they received the full effect. Thus an early intervention strategy such as this can be effective in increasing the participation of females in mathematics and science, but girls participating must be successful in it. Moreover, providing only exposure to mathematics and role models is not enough to enhance achievement.

## Conclusions

An experimental mathematics class with twenty-six seventh-grade female students was conducted during the summer of 1973. The purpose of this all-girls class was to enhance the participation in mathematics and science of moderately gifted females. For each girl in the study there was a control girl and a control boy who was matched with her on ability and parental background variable. The progress of the twenty-six experimental girls through high school and the first two years of college was studied and compared to the progress of the control boys and girls. It was hypothesized that this early intervention strategy would enhance the achievement of the experimental girls so that they would have participated more in mathematics than the control girls and at least at the level of the control boys. (Boys tend to participate more in mathematically related areas.)

If we view the students in the control groups as having had a "weak" treatment (only counseling by mail as to the benefits of accelerating their study of mathematics), and if we view the experimental girls as having had a "strong" treatment (a special class with exposure to role models and an immediate opportunity to accelerate their study of mathematics), one must conclude that for the moderately gifted, the "strong" treatment was not a significantly more effective treatment.

There were eleven girls in the experimental groups, however, who experienced success in the program. These students' participation in mathematics was later enhanced. Thus an early intervention strategy can improve the participation of girls in higher-level mathematics, but the girls have to be successful in the program.

Three factors may have confounded the results. First, the selection criteria for admission to the program was such that several students with very modest SAT scores were admitted to the class. Other special classes conducted at SMPY have used much higher criteria for admission than a

370 on the SAT-M. If the selection score had been 450, there would probably have been a higher success rate but also a very small class. The second explanation is related to the first. Only eleven girls actually received the full extent of the "strong" treatment. Therefore, comparisons in which all twenty-six experimental girls are included actually involve fifteen girls who had a moderate treatment or a failure experience. The eleven girls who did experience the total program were more accelerated, took more mathematics courses in high school and college, and scored higher on the SAT-M in high school than any other group. Third, the numbers were so small that the selection of the control groups was such as possibly to bias the results in that the students were from a variety of different school systems. Some of these school systems may have encouraged more acceleration in mathematics than did the school system in which the experimental girls were enrolled. For example, some of the control boys were enrolled in an accelerated program in a Baltimore City school. Several control boys and girls were enrolled in schools in Maryland's Howard and Montgomery counties, where accelerated programs for the gifted were later developed along the lines of the SMPY model.

On the basis of this study and the results of the evaluations of other accelerated classes conducted by SMPY for both boys and girls, we can draw two major implications for programs for the gifted. First, intensive intervention programs during the summer by an outside-of-school agency such as SMPY are more necessary and effective for the highly gifted than for the moderately gifted. Second, what may be most beneficial for the moderately gifted is the provision of flexible scheduling in the junior and senior high schools to allow these students to accelerate their study of mathematics at a moderate rate within the existing school program.

Perhaps the most encouraging result of the present study is that boys and girls who were matched on measures of ability and socioeconomic backgrounds in grade seven did not differ strikingly in terms of educational experiences, aspirations, and career goals. While one may still conclude that mathematically apt girls may need encouragement to take calculus in high school, it is gratifying to see that most of these gifted students, male and female, are continuing their education beyond high school and aspire to professional careers.

## Notes

We thank Julian C. Stanley for helpful comments on an earlier draft of this chapter.

1. These differences are even more remarkable because most of the students eligible for the mixed-sex classes were considerably apter mathematically than were these thirty-four girls.

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# APPENDIX 7.1: 1980 Follow-Up Questionnaire Used Only for Summer, 1973, Study

*THE JOHNS HOPKINS UNIVERSITY • BALTIMORE, MARYLAND 21218*

*STUDY OF MATHEMATICALLY PRECOCIOUS YOUTH (SMPY)*

*Please reply care of: DEPARTMENT OF PSYCHOLOGY*

*PROFESSOR JULIAN C. STANLEY, Director of SMPY*
*Ms. LOIS S. SANDHOFER, B.A., Administrative Assistant*
*127 Ames Hall, (301) 338-7087*

*Mr. WILLIAM C. GEORGE, Ed.M., Associate Director*
*125 Ames Hall, (301) 338-8144*

*Ms. CAMILLA P. BENBOW, M.A., Assistant Director*
*126 Ames Hall, (301) 338-7086*

QUESTIONNAIRE ON FACTORS IN MATHEMATICS ACHIEVEMENT

Please fill out carefully and completely all of the questions below that apply to you. Please print or type all answers and send the completed questionnaire as soon as possible to SMPY, Dept. of Psychology, The Johns Hopkins University, Baltimore, Md. 21218. All information will be kept strictly confidential; you will not be publicly identified with the information herein in any way.

NAME: ______________________________________________
First Middle Last (Maiden, if applicable)

Permanent address: ______________________________ Telephone (   ) ________
Street City State Zip Area Code

Temporary address if different from above: ______________________________
Street

______________________________ Telephone (   ) ________
City State Zip Area Code

1. Are you currently employed full-time? (circle) yes no

   If yes, please supply the following information about your present and past post high-school occupations in chronological order.

| | Type of Occupation | Duties Involved | Employer | Dates of Employment |
|---|---|---|---|---|
| 1) | | | | |
| 2) | | | | |
| 3) | | | | |

2. Please check the box that applies to you with regard to attendance in an institution of higher education.

   ☐ I am currently a full-time student.
   ☐ I have graduated.
   ☐ I am currently a part-time student after having attended full-time.
   ☐ I am a part-time student.
   ☐ I am not currently enrolled but was previously.
   ☐ I am not and have not been enrolled. (Go to question 3.)

a. Which school are your currently or were you attending? (Do not list schools you may have transferred from.) ______________________

________________________________________________

b. Dates of attendance: ______________________ to ______________________
Month/Year to Month/Year

c. If you have been graduated, date of graduation: ______________
Month/Year

d. What is your major field of study? ______________________

e. If you have switched majors in your undergraduate career, please list your previous major(s) in chronological order: ______________________

f. Please list the titles of the mathematics courses you have already taken in college, your grades in these courses, and when they were taken.

| Mathematics Course | Grade | Dates of Attendance |
|---|---|---|
| 1. | | |
| 2. | | |
| 3. | | |
| 4. | | |
| 5. | | |

If you have taken more mathematics, please continue on a separate sheet of paper.

g. Please list the titles of the science courses you have already taken in college, your grades in these courses, and when they were taken.

| Science Course | Grade | Dates of Attendance |
|---|---|---|
| 1. | | |
| 2. | | |
| 3. | | |
| 4. | | |
| 5. | | |

If you have taken more science courses, please continue on a separate sheet of paper.

3. Please list the college-level mathematics courses you are planning to take in the future: ______________________

________________________________________________

4. Please describe your career goal (i.e., a professor of mathematics or a practicing pediatrician): ______________________

________________________________________________

a. If this career is in the field of science or mathematics, why did you choose this career goal? ______________________

________________________________________________

b. If this career is not in the field of science or mathematics, why did you not pursue a career in those areas? ______________________________

______________________________________________

5. Have you been accelerated in your educational progress? Yes No (Circle.)

a. If no, do you wish you would have been? Yes No (Circle.)

b. If yes, please circle the letter of the applicable sentences to you and then complete them.

1) I skipped the following grades: ________________

2) I took Advanced Placement Program (APP) examinations for which I received ______ credits of advanced placement in college.

3) I was accelerated in subject-matter placement in _____ subjects.

4) I took college courses on a part-time basis as a high-school student for which I received ______ credits of advanced standing in college.

5) Other. (Please specify.) ______________________________

______________________________________________

c. If you were to reconsider your acceleration, which one of the following would best describe your thoughts (check the box)?

☐ I would not accelerate my education at all.

☐ I would accelerate my education somewhat but not as much as I have done.

☐ I would accelerate my education to the degree which I have already done.

☐ I would accelerate my education somewhat more than what I have already done.

☐ I would accelerate my education much more.

6. In general terms, how would you describe the amount of encouragement and support that you have received for your interest in and study of mathematics?

☐ Much support ☐ Some support ☐ Neither support nor discouragement ☐ Some discouragement ☐ Much discouragement

7. How important do you think mathematics will be for your future career?

(Circle.) Very Fairly Slightly Not very Not at all

8. Relative to students who went to high school with you, how well do you feel that you rank in general mathematical ability?

☐ Much superior to my peers

☐ Somewhat superior to my peers

☐ About as well as my peers

☐ Less well than my peers

☐ Much less well than my peers

9. In the past, fewer women than men have pursued careers in mathematics, science, and engineering. The reasons listed below have been mentioned as factors contributing to this. Indicate whether you think these reasons constitute serious problems, minor problems, or no problem to most mathematically talented girls today by placing a (√) in the appropriate column.

| | NO PROBLEM | MINOR PROBLEM | SERIOUS PROBLEM |
|---|---|---|---|
| Long years of formal preparation required | | | |
| Possible conflicts combining a career and family responsibilities | | | |
| Perception of women majoring in engineering or sciences as unfeminine | | | |
| Lack of encouragement from teachers and counselors | | | |
| Perception that the work will be more difficult than they can handle | | | |
| Lack of information about careers in science and mathematics | | | |
| Lack of contact with women employed in those fields | | | |
| Perception of scientists and engineers as cold and impersonal | | | |

I hereby certify that I have read over my responses carefully and thoroughly. They are as complete and accurate as I can make them.

______________________________

Signature

Please return this questionnaire to:

Ms. Camilla P. Benbow
SMPY
Department of Psychology
The Johns Hopkins University
Baltimore, Maryland 21218

# APPENDIX 7.2: Intercorrelations of Talent Search and High-School SAT Scores for the Three Groups

| | Talent Search SAT-M Experimental Girls | Talent Search SAT-M Control Girls | Talent Search SAT-M Control Boys | Talent Search SAT-V Experimental Girls | Talent Search SAT-V Control Girls | Talent Search SAT-V Control Boys | High School SAT-M Experimental Girls | High School SAT-M Control Girls | High School SAT-M Control Boys | High School SAT-V Experimental Girls | High School SAT-V Control Girls | High School SAT-V Control Boys |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Talent Search SAT-M Experimental Girls | (N) | .9491[c] (26) | .9592[c] (26) | .0426 (26) | .1763 (26) | .1661 (26) | .4863[a] (20) | .7427[c] (23) | .5263[b] (25) | -.0382 (20) | .2607 (23) | .2573 (25) |
| Talent Search SAT-M Control Girls | | | .9514[c] (26) | .1038 (26) | .2506 (26) | .2112 (26) | .5023[a] (20) | .7329[c] (23) | .5083[b] (25) | .0417 (20) | .3381 (23) | .1706 (25) |
| Talent Search SAT-M Control Boys | | | | .0900 (26) | .2149 (26) | .1805 (26) | .3943[a] (20) | .7512[c] (23) | .5267[b] (25) | .0070 (20) | .3455 (23) | .1641 (25) |
| Talent Search SAT-V Experimental Girls | | | | | .9001[c] (26) | .9176[c] (26) | .4638[a] (20) | -.0465 (23) | .1407 (25) | .8527[c] (20) | .6006[c] (23) | .4773[b] (25) |
| Talent Search SAT-V | | | | | | .9401[c] | .4764[a] | .0479 | .0583 | .7083[c] | .6685[c] | .5384[b] |

| | Talent Search SAT-M Experi-mental Girls | Talent Search SAT-M Control Girls | Talent Search SAT-M Control Boys | Talent Search SAT-V Experi-mental Girls | Talent Search SAT-V Control Girls | Talent Search SAT-V Control Boys | High School SAT-M Experi-mental Girls | High School SAT-M Control Girls | High School SAT-M Control Boys | High School SAT-V Experi-mental Girls | High School SAT-V Control Girls | High School SAT-V Control Boys |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Talent Search SAT-V Control Boys | | | | | | | .3993[a] (20) | -.0330 (23) | .0754 (25) | .7853[c] (20) | .5183[b] (23) | .5290[b] (25) |
| High School SAT-M Experi-mental Girls | | | | | | | | .4757[a] (18) | .3956[a] (20) | .3004 (20) | .5737[b] (18) | .5239[b] (20) |
| High School SAT-M Control Girls | | | | | | | | | .5837[b] (22) | -.0071 (18) | .4742[a] (23) | .1289 (22) |
| High School SAT-M Control Boys | | | | | | | | | | .1486 (20) | .4123[a] (22) | .4973[b] (25) |
| High School SAT-V Experi-mental Girls | | | | | | | | | | | .4592[a] (18) | .3146 (20) |

| | Talent Search SAT-M Experimental Girls | Talent Search SAT-M Control Girls | Talent Search SAT-M Control Boys | Talent Search SAT-V Experimental Girls | Talent Search SAT-V Control Girls | Talent Search SAT-V Control Boys | High School SAT-M Experimental Girls | High School SAT-M Control Girls | High School SAT-M Control Boys | High School SAT-V Experimental Girls | High School SAT-V Control Girls | High School SAT-V Control Boys |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| High School SAT-V Control Girls | | | | | | | | | | | | .5610[b] (22) |
| High School SAT-V Control Boys | | | | | | | | | | | | |

[a] $p \leq .05$.
[b] $p \leq .01$.
[c] $p \leq .001$.