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Association for Women in Mathematics

Volume 14, Number 3 NEWSLETTER May-June 1984

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PRESIDENT'S REPORT

Future programs. AWM is not only concerned with improving the status and productivity of women working in the mathematical sciences, but also with encouraging girls and women of all ages in their mathematical studies. Most of us would like to do more, but don't know what to do. A group called EQUALS at the University of California at Berkeley has been studying the problem of helping precollege girls in mathematics and has developed a highly successful training program for teachers in the California school systems. Having received a half million dollar grant from the Carnegie Foundation, EQUALS is now extending its program to a number of new sites in other states.

Those of us who teach women undergraduates are naturally interested in understanding what their precollege experience has been like. Also, many ideas for helping high school girls in mathematics are equally applicable to college women, especially those who come with very weak backgrounds. Therefore AWM is very pleased to have Kay Gilliland, one of the coordinators of EQUALS, as a featured speaker in our program at the joint American Mathematical Society-Mathematical Association of America meeting in Eugene, Oregon in August. The session will include an active interchange of ideas on what we can do at the college and university level.

Volunteers needed. AWM has found that its fundraising efforts are often more successful on the local level than on the national level. We have received a number of grants in the Boston area because of local efforts there, but we need help in other areas of the country, particular metropolitan areas. If you would like to help we need you! Please contact me or Eleanor Palais, chair of the Fundraising Committee.

Linda Preiss Rothschild
Department of Mathematics
University of California, San Diego
La Jolla, CA 92093

LETTER FROM THE EDITOR

The *Newsletter* meets High Technology! I hope you like the new look. If any of you have any suggestions or comments on the format, please let me know.

I used the jump-feet-first-into-the-word-processor approach (how else do you learn how to Set Printer File?). So this issue has taken a little longer to get together than most, but I think I'm hooked (except for those moments wondering why suddenly <u>everything</u> is italicized and .:.). And in the future the machine should actually be a time-saver. Not to mention that I can now sell my stock in Liquid Paper.®

Two biographies of Sofia Kovalevskaya have recently appeared. *Little Sparrow: A Portrait of Sophia Kovalevsky* by Don Kennedy is published by the Ohio University Press and is $12.95 (softcover). *A Convergence of Lives: Sofia Kovalevskaia: Scientist, Writer, Revolutionary* by Ann Hibner Koblitz (author of several *Newsletter* articles) is published by Birkhäuser Boston and is $19.95 (hardcover). I haven't read either of them yet, but they're sitting on my shelf, waiting for summer. Pat Kenschaft's comparative review will appear in the *Newsletter* soon, hopefully in the next issue.

In the next issue will appear an appreciation of the Russian mathematician I.G. Bashmakova on her 60th birthday. We regularly reprint appreciations and obituaries. They're usually for foreign mathematicians. The American journals don't seem to include many of these any more. I invite all of you to write similar articles for the *Newsletter*: they would be a service to the entire mathematical community, not just to AWM.

Also, an essay review by Claudia Zaslavsky appears in this issue. I would like to encourage you to write book reviews. Or if you haven't the time for in-depth analysis, write book reports as I sometimes do for this column.

While I'm discussing possible articles for all of you to write: some time ago, we attempted to start a section to keep us all up-to-date at the generalist level on important developments in mathematics. The section died for lack of contributions. Send me some articles, and we can revive it.

Anne Leggett
Department of Mathematics
Loyola University
6525 N. Sheridan Road
Chicago, IL 60626

MATHEMATICAL ASSOCIATION OF AMERICA CITATION

IN HONOR OF THOSE WHO HAVE FURTHERED THE PROGRESS OF MATHEMATICS BY ENHANCING SIGNIFICANTLY THE STATUS OF WOMEN IN MATHEMATICS

History will record the 1970's as the decade of Women's Rights, a time when a liberating movement captured the imagination and stirred the conscience of the Western World. Led by a dedicated group of women and men, the movement succeeded in awakening the expectations of women for social, political, and economic equality and prodded a culture based on justice, but often bound by unreasoning tradition, to take the first significant steps toward equal rights for women.

The struggle is not over: the Women's Movement has not achieved all of its goals. However, the achievements have been so great and the benefits to society so obvious that it is right to pause to acknowledge and honor the many women who have blazed the trail.

The Women's Movement in mathematics has been especially strong. Many women - and more than a few men - have worked hard and effectively to convince women that they have potential for excellence in mathematics and that they should receive recognition and rewards commensurate with their achievements. Organizations have been created for the vigorous pursuit of these goals, such as the Women and Mathematics program of the Mathematical Association of America, and the Association for Women in Mathematics.

Women have achieved prominence in research, teaching, writing, and editorial responsibilities, and have risen to the highest levels of leadership in mathematical organizations. Public recognition for these achievements has inspired other women to make full use of their abilities, in mathematics as in all affairs, with pride and confidence. The Board of Governors of the Mathematical Association of America recognizes and honors their many contributions.

The Board directs the Secretary of the Association to prepare a special certificate of recognition and to place it on permanent display in the Dolciani Mathematical Center, headquarters of the Association.

January 24, 1984

DISSERTATION FELLOWSHIPS

The Sloan Foundation is starting a new program of doctoral dissertation fellowships in mathematics beginning with academic year 1984-85. Twenty-five one-year fellowships will be awarded, each carrying a stipend of $8,000 plus tuition for one academic year. A panel of distinguished mathematicians chosen by the Foundation will select the fellows from a pool of candidates nominated by twenty-six leading graduate departments of mathematics. Award winners must be free of other duties during the academic year 1984-85; they may not be employed as teaching assistants or assistants in research; they may not hold other substantial fellowships; and they must have a reasonable expectation of completing the dissertation in the fellowship year.

EQUITY HANDBOOK

Handbook for Conducting EQUITY ACTIVITIES in Mathematics Education, Helen Neely Cheek, Editor, with Gilbert J. Cuevas, Judith E. Jacobs, Genevieve Knight, and B. Ross Taylor, has been published by the National Council of Teachers of Mathematics. The handbook includes suggestions for conducting mathematics equity surveys, designing and organizing equity conferences and other teacher inservice activities, developing networking strategies, and developing curriculum and instructional strategies which deal with equity issues in mathematics. In addition, a resource list of mathematics equity materials in included in the appendix, together with "state-of-the-art" papers on underrepresented groups in mathematics.

SELF-CONFIDENCE IN MATHEMATICS

A report by Sally Wilding, Lynn Cleary, and Margie Hobbs in the January, 1984 *Mathematics Teacher*, p. 69, tells about three courses offered at the University of Maryland to students to help them gain self-confidence in mathematics. From the article: Over five hundred students have participated in these courses since the first of them was offered in the spring of 1979. The mathematics confidence-building program began as a part of the university's remedial mathematics program. ... Progression through three developmental stages is considered necessary for success in gaining confidence in mathematics. The first stage is characterized by an increased self-awareness of attitudes and behaviors toward mathematics. In the second stage, the students begin the process of changing self-defeating attitudes and behaviors toward mathematics. The final stage is characterized by the breaking of math-avoidance and math-anxiety behavior patterns. For course syllabi write to Sally Wilding or Lynn Cleary, University of Maryland, Department of Mathematics, College Park, MD 20742.

REPORT OF THE TREASURER

January 17, 1984

Accounting for the period June 1, 1983 to December 31, 1983

Balance, June 1, 1983			$41,272.86
Total Assets, June 1, 1983	$41,384.74		

Note: The figure $41,384.74 represents $41,272.86 cash-on-hand plus 5 shares of Washington Water Power, valued at $111.88 as of May 31, 1979.

<u>Receipts</u>

Dues – Individuals	$11,475.20		
Families	980.00		
Institutional	3,815.00		
Advertising fees	340.00		
Contributions	797.00		
Interest	1,303.79		
Miscellaneous	288.54		
		$18,999.53	

<u>Expenses</u>

Wages & FICA (1)	$3,310.23		
Newsletters (2)	2,551.95		
Dues and fees (3)	80.00		
AWM meetings	103.29		
Operating expenses (4)	1,167.69		
Speakers' Bureau (5)	2,044.32		
Raytheon grants (6)	4,530.00		
Bulk mailing deposits (7)	520.00		
Miscellaneous	37.54		
		$14,345.02	
Balance, December 31, 1983			$45,927.37

(1) Part-time Administrative Assistant.
(2) Typing, postage, and printing for 3 issues.
(3) Conference Board of the Mathematical Sciences and the Massachusetts Incorporation fee.
(4) Postage, phone, supplies & duplicating.
(5) Wages for the Director of the Speakers' Bureau plus phone, postage, and duplicating expenses.
(6) Grants to women high school teachers to learn PASCAL and/or Data Structures.
(7) Deposits placed with the Boston Post Office against which bulk mailings of Newsletters and Dues Notices are charged.

Membership Statistics: Our mailing list totals 1300, including institutions and members in Canada and abroad.

Respectfully submitted,

Donna Beers
Treasurer

150th NATIONAL MEETING OF THE AAAS

Pre-College Education in the Mathematical Sciences: New Goals and Content

The session, entitled "Pre-College Education in the Mathematical Sciences: New Goals and Content", will take place on Friday, May 25, 1984, 9:00 a.m.-12:00 noon, in the New York Hilton Hotel, Room Nassau A. A synopsis of the symposium appears below. It was organized by Herb Greenberg, with Stephen Willoughby and Richard Schaeffer (University of Florida) as co-organizers.

Herb Greenberg will preside over a session consisting of the following talks:

- Stephen Willoughby (New York University), "Realities and Opportunities in Pre-College Mathematics Education".
- Anthony Ralston (SUNY at Buffalo), "The Impact of Computer Science and Technology".
- Richard DiPrima (Rensselaer Polytechnic Institute), "Modern Applications of Mathematics and Their Role".
- Richard L. Schaeffer (University of Florida), "Statistics and Probability in the K-12 Mathematics Curriculum - Why and How".
- James M. Landwehr (Bell Laboratories), "Exploring Data - Statistical Activities for Junior and Senior High."

Synopsis of Symposium

Everyone who is at all concerned knows that American mathematics and science pre-college education needs attention. Parents, legislators, government agencies, and professional organizations have all again begun looking for the most effective way to change the status and professional level of the teachers, to enrich the curricula, and to provide the necessary technology.

One vital component of this activity must be a set of goals that meet the needs of society, the economy, and young people and also reflect the best projections that professionals in teaching and in mathematics can provide. The symposium in the first three talks will examine mathematical and computational goals from the perspective of: the classroom (the views of teachers and mathematics educators), computers (the influence of computer science on the teaching of mathematics), and the use of mathematics and computation in applications.

Following these three general presentations, the second part of the Symposium will turn to a specific key element in teaching students how to solve real problems: an appreciation of statistical thinking as it relates to the collection, display, summarization and interpretation of data.

The ASA-NCTM Joint Committee on Statistics and Probability has been developing curriculum guidelines and has collected and written materials that can be used by teachers, at a variety of levels, to introduce statistics and probability into the mathematics curriculum. The last two speakers will present the approach developed by the Joint Committee and will discuss some suggested statistical activities in detail.

Symposia at the May 1984 Annual Meeting related to mathematics and mathematics education

Rolf Sinclair	The Frontiers of the Natural Sciences
Stephen Maurer	Discrete Mathematics as a Rival to Calculus in the Core of Undergraduate Mathematics
Saul Krasner	The Chaotic State and Its Approach
Robert Rumely	Cryptography and Number-Theoretic Algorithms
James Gidley	Nearly Optimal Solutions in Linear Programming: Mathematical Issues and Implications for Applied Research
Melvin Ciment	Plans and Developments in Scientific Supercomputing
Robert Miura	Some Mathematical Questions in Biology--DNA Sequence Analysis
F. Alberto Grunbaum	Mathematical Problems in Medical Imaging

Herbert Greenberg	New Goals for Mathematics Education
Edward J. Wegman	Journeys into Higher Dimensions: Graphics in Mathematics, Statistics, and Perception
Steve J. Brams	Can Game Theory Model Real-World Conflicts?
Edward J. Wegman	Brain Structure, Learning and Memory
A. D. Wyner	Information Theory in the 80's
Manfred Kochen	Advances in Computer/Information Systems
Scott Paul Robertson	Cognition and Computing
Judith Tanur	Election Forecasting: Early and Last-Minute
Walter Cory	The Crises in Science and Mathematics Education
Michael Guillen	Looking Back at the Future of Science and Mathematics Education in America
Alphonse Buccino	The Politics of Science Education
Frank Starr	Turf Protection vs. Excellence in Science and Mathematics Education
Sheila M. Pfafflin	Increasing Participation in Science and Mathematics during the Precollege Years

REPORT ON GRADUATE EDUCATION

Recently the National Commission on Student Financial Assistance issued a report on the future of graduate education in America. John Brademas, President of New York University, chaired the Commission's Graduate Education Subcommittee which prepared Signs of Trouble and Erosion: A Report on Graduate Education in America. The report was unanimously approved by the twelve members of the Commission, who were appointed, four each, by President Ronald Reagan, House Speaker Thomas P. O'Neill, Jr., and Senate President Pro Tempore Strom Thurmond.

The report is the outcome of a year-long study by the Commission in response to a Congressional mandate to review Federal support for graduate students. Because the research and teaching functions of universities are inseparable, the Commission examined the question of student financial assistance in the context of the graduate enterprise as a whole. We focused chiefly on master's and doctoral programs in the arts and sciences. One of the major issues the Commission considered was that women today are not equally represented in graduate schools at the doctoral level.

The Commission found that:

* although women comprise half the population and half the total number of graduate students, they received only one-third of the graduate degrees;

* women doctoral recipients are concentrated in education and the social sciences, and are severely underrepresented in the physical sciences and engineering; and

* in the latter fields, women received, respectively, 3.7 percent and 1.0 percent of the doctorates awarded.

The Commission specifically recommended that Federal fellowship support for women be increased. Special attention should be given programs to augment participation of women in the sciences and engineering. Career opportunities for women in these fields should be enhanced through expanded research assistantships and new support for promising young faculty. The Commission also urged attention to several problems that prevent full participation by women in graduate education: disproportionate loan burdens, cultural factors that discourage women from entering particular fields, and biases favoring men in the awarding of fellowships and assistantships.

GEOMETRY PROOF WRITING: A NEW VIEW OF SEX DIFFERENCES IN MATHEMATICS ABILITY

by Sharon Senk, Syracuse University, and Zalman Usiskin, University of Chicago
Sharon Senk taught mathematics at Newton High School, Newton, Massachusetts, and recently completed her Ph.D. work in education at the University of Chicago. Her current interests are the learning of geometry and the history of mathematics curriculum reform.
Zalman Usiskin is professor of education at the University of Chicago. His major interests are policy matters relating to the scope, sequence, and underlying structure of the K-12 mathematics curriculum.
Reprinted from *American Journal of Education* Vol. 91, No. 2, February 1983, pp.187-201, by permission of the authors and the publisher, The University of Chicago Press.

A study of 1,364 students in 74 senior high school classes in which geometry proof was taught found equal ability among males and females to write geometry proofs. These results held as well for select high-achieving subsamples. These findings and data from other recent studies suggest that girls and boys perform equally well even on complex mathematical tasks if both in-class and out-of-class exposure to the tasks is equal.

Sex differences in mathematics performance favoring males have been reported for many years [Maccoby and Jacklin 1974]. Until recently, studies rather consistently indicated that, although no systematic sex differences in performance are observed in young children, by early adolescence boys begin to surpass girls on many mathematical tasks, and by the end of high school the gap between males and females is both statistically and educationally significant. Yet some recent studies report declines in differences or no differences at all [Armstrong 1981]. The largest and most consistent sex differences reported have been on so-called high-level cognitive tasks such as applications of mathematics in real-world situations or problem solving. These differences seem particularly marked among higher-ability students [Benbow and Stanley 1980/81]. Often differences in performance are attributed to sex differences in tests of spatial ability [Maccoby and Jacklin 1974; Benbow and Stanley 1980/81].

Given these reported differences, one might expect significant sex differences in performance on doing geometry proofs, which requires some spatial ability, qualifies as a high-level cognitive task, and is considered among the most difficult processes to learn in the secondary school mathematics curriculum. The first purpose of this article is to report that, in the first large-scale study of geometry proof-writing performance ever conducted in the United States, we have found no consistent sex differences. The second purpose of this article is to propose an explanation for the inconsistent patterns of sex differences that characterize recent studies.

Design

The data we present are from the Cognitive Development and Achievement in Secondary School Geometry (CDASSG) project and represent only one of many aspects of geometry learning investigated by the project.[1] The CDASSG sample includes 2699 students in 99 geometry classes from 13 public high schools in five states (table 1). The schools were chosen to represent a national cross-section of educational and socioeconomic conditions. Black, Hispanic, and Oriental minorities were sizable in a few schools. Within the schools, the subsample for this study includes all students in the geometry classes that had studied proof writing and whose teachers gave permission for testing, a total of 1,520 students in 74 classes from 11 high schools in five states. At the time of the spring testing, more than 95 percent of the students were age 14-17, and the mean age was 16 years, 2 months.

The study was conducted during the 1980-81 school year. During the first week of school, students were given a 25-minute test for entering knowledge of geometry

TABLE 1

Sex by Track for the Entire CDASSG Project Sample and for All Those Who Took the EG and Proof Tests

	CDASSG PROJECT SAMPLE				PROOF SAMPLE			
		Students in Sample				Students in Sample		
TRACK DESCRIPTION	Number of Classes	Female	Male	Total	Number of Classes	Female	Male	Total
Highest of three tracks	15	165	183	348	15	136	164	300
Higher of two tracks	4	28	48	76	4	20	35	55
Middle of three tracks	27	352	328	680	25	233	212	445
Lower of two tracks	13	154	177	331	11	99	87	186
Lowest of three tracks	14	164	200	364	0	0	0	0
Untracked	26	452	448	920	19	186	192	378
Total	99	1,315	1,384	2,699	74	674	690	1,364

terminology and facts.[2] In the last month of the school year, students took the 40-minute Comprehensive Assessment Program (CAP) [1980] standardized geometry achievement test and one of three forms of a 35-minute proof test devised by CDASSG project personnel.[3] All tests were administered by classroom teachers during the normal school day and monitored by project representatives. The proof test forms were alternated among the students so that approximately one-third of the students in each class received each form.

Three forms of a proof test were devised so that performance on a greater number of proofs could be analyzed. Each form contained six items: the first required the student to fill in four missing statements or reasons in a proof; the second required translation of a verbal statement into an appropriate figure, "given", and "to prove"; and the last four required the student to write complete proofs. All items were representative of standard geometry proofs, ranging from easy to difficult, covering congruent and similar triangles, parallel lines, and quadrilaterals. Sample proof items are shown in figure 1, and scores on these proofs are presented in table 2. Two pilot studies of the proof tests had been conducted to insure appropriate test length, clarity of instructions, and approximate balance of item difficulty and subject matter across forms, but no effort was exerted to make the forms statistically equivalent.

No large-scale assessment of proof-writing performance had been undertaken prior to this study, perhaps because of perceived difficulties in grading proofs and in finding items that would be fair for students who studied from texts with different terminology and theorem order. Neither of these potential difficulties seems to have arisen, perhaps because of the pilot studies and grading procedures we used.

Eight experienced high school mathematics teachers (six male, two female) were hired to grade the proof tests. Proof items were graded on a scale from 0 to 4 based on general criteria developed by Malone, Douglas, Kissane, and Mortlock [1980].

0. Student writes nothing, writes only the "given", or writes invalid or useless deductions.
1. Student writes at least one valid deduction and gives reason.
2. Student shows evidence of using a chain of reasoning, either by deducing about half the proof and stopping or by writing a sequence of statements that is invalid only because it is based on faulty reasoning early in the steps.
3. Student writes a proof in which all steps follow logically, but in which there are errors in notation, vocabulary, or names of theorems.
4. Student writes a valid proof with at most one error in notation.

A. FORM 2, ITEM 3

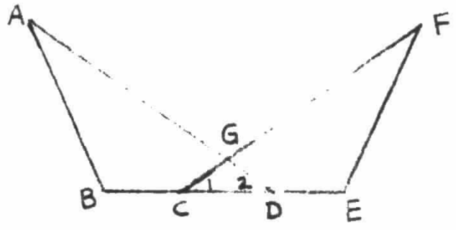
Write this proof in the space provided.

GIVEN: $\overline{BD} \cong \overline{EC}$

$\angle 1 \cong \angle 2$

$\angle B \cong \angle E$

PROVE: $\overline{AB} \cong \overline{EF}$



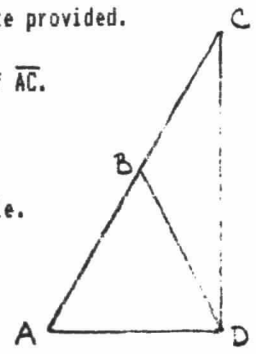
B. FORM 1, ITEM 6

Write this proof in the space provided.

GIVEN: B is the midpoint of $\overline{AC}$.

AB = BD.

PROVE: $\angle$CDA is a right angle.



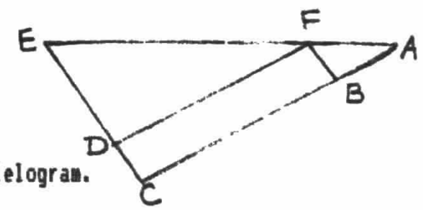
C. FORM 2, ITEM 5

Write this proof in the space provided.

GIVEN: $\triangle ABF \sim \triangle ACE$

$\triangle FDE \sim \triangle ACE$

PROVE: BCDF is a parallelogram.



D. FORM 3, ITEM 4

Write this proof in the space provided.

GIVEN: Quadrilateral HIJK

HI = HK

IJ = JK

PROVE: $\angle I \cong \angle K$

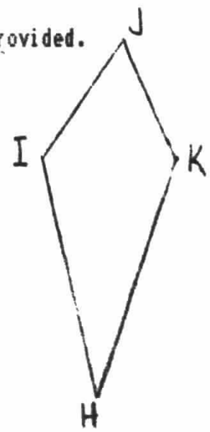


FIG.1.--Sample items from the CDASSG proof tests

TABLE 2

Scores for Items Shown in Figure 1

Test Item	Mean	Standard Error
A. Form 2, item 3:		
Female (N = 214)	2.98	.11
Male (N = 241)	3.09	.10
B. Form 1, item 6:		
Female (N = 219)	.83	.07
Male (N = 235)	.79	.07
C. Form 2, item 5:		
Female (N = 214)	.84	.09
Male (N = 241)	1.20	.10
D. Form 3, item 4:		
Female (N = 241)	2.27	.12
Male (N = 216)	2.12	.13

NOTE.--Item A was the easiest of the 12 full proofs; item B was the most difficult. Item C most favored the boys; item D most favored the girls.

Before grading each item, graders discussed the application of the general criteria to that item. Every item on each student's test was scored independently by a different pair of graders who had no access to the student's name, sex, or school. Interrater agreement ranged from 81 percent to 95 percent across the 18 items, averaging 86 percent. Less than 2 percent of the scores of the pair of graders differed by more than one point. When the two graders' scores disagreed, a third independent blind reading was undertaken, and the median of the three scores was chosen as the item score. The grading of the 1,520 test papers was completed in 40 person-days.

Two measures of proof-writing performance were calculated. The first, called "total score," is the customary sum of the item scores, with a maximum possible of 24. The second, called "number of proofs correct," is the number of full proof items upon which the student scored 3 or 4. The maximum possible "number of proofs correct" is 4.

Findings

We report here only on those 1,364 students who took a proof test and the entering geometry (EG) test. Of these, 690 are male and 674 are female, yielding a ratio within one-half percent of sex ratios in both national and school populations at ages 14-17 [U.S. Department of Commerce 1980]. The breakdown of sex by track (table 1) shows that more males than females are in higher-track classes. The students range from seventh to twelfth graders, with 63 percent in tenth grade (table 3).

TABLE 3

Sex by Grade in School for Those Taking the EG and Proof Tests

	GRADE							
SEX	7	8	9	10	11	12	NA	TOTAL
Male	0	12	94	437	100	31	0	674
Female	1	6	103	426	125	28	1	690

For this sample, total score means and standard deviations for the three forms of the proof test are, respectively, 12.59 ± 5.43, 14.27 ± 5.22, and 12.98 ± 6.37. Differences between these means are significant, as are differences in the shapes of the distributions, so the three proof test forms are not equivalent.[4] As a consequence, data from this study are reported separately by form.

Mean scores on the proof tests are reported by sex in table 4. Raw mean total scores are higher for males on two forms and for females on the third form, but none of the differences is statistically significant. The mean number of proofs correct is higher for males on all three forms, but never significantly.

Mean scores for girls are significantly lower than mean scores for boys on the EG test.[5] When the proof total scores are adjusted using ANCOVA for this entering geometry knowledge, adjusted mean proof total scores for females are higher than for males on all forms and significantly higher on Form 3. When the mean number of proofs correct are similarly adjusted, the results favor the females on all three forms, though never significantly.

For the 18 items viewed individually, mean scores for the sexes are significantly different at the .05 level on two items, on a full proof favoring males, the other a translation favoring females. At this significance level, 2 differences in 18 can be expected by chance, and no pattern in the content of items favoring either sex (even when statistical significance was ignored) was observed.

Thus, although girls enter the high school geometry course with generally less geometry knowledge, at the end of the year there is no consistent difference between the sexes on proof-writing performance. This finding is particularly striking not just because of the widely held belief that boys are better than girls at high-level mathematical reasoning but because, on our other measure of geometry performance at the end of the school year, the CAP test, boys' unadjusted means are significantly higher than girls' unadjusted means. Yet when CAP scores are adjusted by ANCOVA for scores on the EG test, adjusted means for girls and boys are nearly identical.[6] Consequently, the differences between boys' and girls' performance on the standardized geometry test at the end of the year result largely from differences in entering knowledge of geometry. That is, when differences in entering geometry knowledge are taken into account, girls and boys learn both geometry problems and proof writing equally well.

TABLE 4

Mean Proof Scores for All Students Taking the Entering Geometry (EG) and Proof Tests

Form and Sex	Mean Raw Total Score	Mean Total Score Adjusted for EG	Mean Raw Number of Proofs Correct	Mean Number of Proofs Correct Adjusted for EG
1:				
Female (N = 219)	12.34 (.43)	12.91 (.36)	1.50 (.08)	1.61 (.07)
Male (N = 234)	12.87 (.42)	12.33 (.36)	1.55 (.08)	1.45 (.07)
2:				
Female (N = 214)	13.93 (.44)	14.65 (.36)	1.72 (.10)	1.88 (.08)
Male (N = 240)	14.60 (.41)	13.95 (.34)	1.97 (.09)	1.83 (.08)
3:				
Female (N = 241)	13.05 (.49)	13.63 (.41)	1.64 (.10)	1.75 (.09)
Male (N = 216)	12.82 (.52)	12.18 (.43)*	1.75 (.11)	1.62 (.09)

NOTE.--Numbers in parentheses are standard errors.
* Difference is significant at the .05 level.

Benbow and Stanley's [1980/81] study of mathematically precocious youth (SMPY) led them to conclude that the "greatest disparity between the girls and boys is in the upper ranges of mathematical ability." Because of the publicity surrounding their results, we examined three subsets of high-achieving students, each in some way comparable to Benbow and Stanley's sample. The first subset consists of the top-scoring students on each form of the proof tests. These were the 20 students whose total scores were 22-24 on Form 1 (only two students received perfect scores on this form), the 20 students with perfect total scores on Form 2, and the 31 students with perfect total scores on Form 3. This subset has 37 females and 34 males. A second subset consists of students in grades 7 or 8 during the study and thus accelerated at least two years. Among this subset of 12 girls and 7 boys no significant differences by sex were found between the means on either the total proof score or the number of proofs correct, adjusted or unadjusted. The third subset consists of those in the sample who scored in the top 3 percent nationwide as determined by the CAP norms, comparable to the SMPY study prerequisite that students score in the top 3 percent nationwide on a standardized mathematics achievement test. This subset consists of 89 students--31 females and 58 males in grades 7-10--and indicates that, as in the Benbow and Stanley sample, significantly more males than females score at the higher levels on a multiple-choice test of standard content. But, as shown in table 5, proof-writing performance for this third subset indicates no sex-related differences. Thus our study indicates equal proof-writing performance by high-achieving girls and boys.

In summary, we have found no consistent pattern of statistically significant differences favoring either sex on any form of our proof tests. This finding holds in both our complete sample of 1,364 mixed-ability students and the three highly select subsets we examined. Thus we conclude that there are no sex differences in geometry proof-writing performance.

Our findings refute the necessary existence of sex-related differences on geometry tasks requiring high-level reasoning. They cast suspicion on hypotheses of sexual differences in ability to perform other high-level cognitive tasks in mathematics. And they raise the question of what accounts for the inconsistencies in achievement by sex found between older and more recent studies and among recent works.

TABLE 5

Mean Proof Scores for Students Scoring in the Top 3 Percent Nationwide on the CAP Test According to CAP Norms

Form and Sex	Mean Proof Total Score	Mean Number of Proofs Correct
1:		
Female (N = 9)	20.33 (.71)	3.11 (.26)
Male (N = 19)	20.11 (.41)	2.95 (.16)
2:		
Female (N = 12)	22.58 (.57)	3.75 (.13)
Male (N = 25)	22.00 (.50)	3.52 (.15)
3:		
Female (N = 10)	22.60 (.37)	3.80 (.13)
% Male (N = 14)	21.93 (.46)	3.57 (.20)

NOTE.--Numbers in parentheses are standard errors. Since about 56 percent of high school seniors have taken geometry (12), this subsample represents about the top 1.5 percent of the age cohort population. It includes 4.2 percent of those in the larger CDASSG study who took the CAP test.

Related Studies

Our study is not the first to find equal mathematics performance by male and female high school students. For example, Swafford [1980] found no sex differences in algebra achievement among first-year algebra students. The 1977-78 National Assessment of Educational Progress (NAEP) and the 1978 Women in Mathematics survey [Armstrong 1981] concluded that at age 13 girls are better than boys at computation and about equal in algebra and problem-solving skills. Although by the end of high school boys have surpassed girls in problem-solving performance, these two studies found no significant differences between boys' and girls' scores on tests of computation and algebra.

Since the mid-1970s, several studies have reported increased participation by females in mathematics courses and few or no differences on spatial tasks [Becker 1978, Jacklin 1979, Armstrong 1981, Fennema 1981]. We agree with Jacklin that older studies and reviews [e.g., Maccoby and Jacklin 1974] may not describe very accurately the world today, and we urge researchers to proceed with caution when basing hypotheses or conclusions on them.

However, sex differences have shown up even in recent studies. Males have outperformed females on tests of problem solving [Armstrong 1981], consumer applications [Swafford 1980], and the mathematics portion of the Scholastic Aptitude Test (SAT-M) [Benbow and Stanley 1980/81].

Confounding the problem, researchers have come to different conclusions regarding sex differences, even when working from the same data. For example, the Project TALENT study originally reported significant sex differences in mathematics scores in grade 12 favoring males [Flanagan, Davis, Dailey, Shaycroft, Orv, Goldberg, and Neyman 1964], yet when Wise, Steel, and MacDonald [1979] reanalyzed these data controlling for the number of years students had studied mathematics, testing a hypothesis of Fennema [1974], no significant sex differences were found.

Moreover, the conclusion of Benbow and Stanley [1980/81] that "sex differences result from superior male mathematical ability" disagrees with Fox and Cohn's conclusions [1980] from the same data.

Although Fennema's hypothesis of differential course-taking explains many sex differences, both Benbow and Stanley's study of intellectually gifted students and NAEP data [Armstrong 1981] from a national probability sample show that differential participation in formal courses is not the sole factor.

Resolving Inconsistencies among Recent Studies

Why do some studies show great sex differences in mathematics performance whereas others do not? Our explanation relies on comparing the test items with students' formal and informal educational experiences. When test items cover material that is taught and learned almost exclusively in the classroom, no pattern of sex differences tends to be found. This holds for routine tasks such as computation and algebra exercises [Armstrong 1981, Swafford 1980], and our study shows that it holds even for such a high-level cognitive task as geometry proof writing. In contrast, when test items attempt to be purposely unlike the exercises in commonly used texts, as in tests of problem solving [Armstrong 1981], consumer applications [Swafford 1980], and the SAT-M [Benbow and Stanley 1980/81], males outperform females. Our entering geometry test appears to be somewhere in between, with questions covering content found in junior high school texts but often not taught, and only moderate sex differences arise. Thus the studies of mathematics performance we have cited fit the following general pattern: the more an instrument directly measures students' formal educational experiences in mathematics, the less the likelihood of sex differences.

Benbow and Stanley's conclusion regarding the mathematical ability of talented boys and girls rests on the assumption that the SAT-M is a test whose items are relatively and equally unfamiliar to the sexes. However, unfamiliarity is a quality relating item and student that varies greatly among students, and scores on this kind of test could easily be affected by experiences outside the mathematics classroom. These informal experiences appear to be different for the sexes throughout schooling [Burton 1979]. For example, more boys than girls participate in mathematics contests, and more boys than girls work with computers [Tinker 1981]. Furthermore, SMPY talented boys have tended to be more interested in mathematics than SMPY talented girls [Tobin and Fox 1980]. Since better students are more likely than average students to be involved with school subjects outside the classroom, the differences in interests between boys and girls could easily result in greater differences in knowledge between the sexes among better students than among average or poorer students.

In this regard, geometry proof is a unique topic. Work with mathematics contests, computers, or advanced reading in mathematics seldom involves geometry proofs. So geometry proof writing is unlikely to be encountered even by the most interested student outside of geometry classes. Since the time of Euclid, geometry proof has been considered a model for deductive reasoning. Abstract symbols and laws of inference are often consciously applied in doing these proofs. Geometry proof writing is quite difficult for students; over one-fourth of our sample had zero proofs correct, despite the existence of easy proofs on each form and despite students having spent a significant portion of the year on the topic.[7] No algorithm exists that will handle all geometry proofs. These attributes of geometry proof writing confirm its classification as a high-level cognitive task. Thus geometry proof items provide a hard test of reasoning, yet they are likely to have been experienced by the sexes equally both inside and outside of class.

Given the documented disparity in the social and informal educational experiences of boys and girls relating to mathematics, to define mathematical ability by a score on a test of supposedly unfamiliar content forces a sex bias upon the research design. We propose that mathematical ability not be defined by tests of problem solving, spatial ability, or SATs, for which out-of-class experiences can play such an important role. Instead, we suggest that mathematical ability be defined as the extent to which students learn routine or complex tasks involving topics that are not encountered even by interested students outside the classroom. Proof writing is one of the few topics in the standard curriculum that has sufficient complexity and difficulty to be used as a measure of mathematical ability and with which formal and informal encounters are likely to be equal for the sexes. Our results with proof writing, together with our analysis of other studies, lead us to believe that boys and girls are of equal mathematical ability.

In summary, we have found that, when male and female students are tested on writing geometry proofs, a high-level cognitive task encountered almost exclusively in the classroom, no consistent pattern of sex differences in performance exists. Our results hold for both our total national sample of mixed-ability students and for select high-scoring subsamples. Our findings and data from other recent studies suggest that, when experience can be controlled, regardless of the difficulty or complexity of the items, girls and boys perform equally well.

NOTES

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-1. Copies of the final report of the CDASSG project, including all unpublished instruments mentioned here, are available from Zalman Usiskin, University of Chicago, Department of Education, 5835 S. Kimbark Avenue, Chicago, Illinois 60637, for $10, which includes handling and mailing.

-2. The entering geometry (EG) test is a 19-item multiple-choice test created by the CDASSG project staff, utilizing the easier items from a 50-item test given in a study of entering geometry knowledge by Jane Macdonald, Ohio State University, 1971. The K-R 20 realibility for the EG test is .77.

-3. The K-R 20 reliability for the CAP test is reported as .89; Cronbach's α reliabilities for the three forms of the proof tests are .86, .85, and .88, respectively.

-4. One-way ANCOVA of total score by form yields $F(2,1361) = 9.09$, $p<.0001$. For the shape of the distributions of total score by form, $\chi^2(48) = 125.17$, $p<.0001$.

-5. Mean EG scores for females and males, t values: for Form 1 subsample--10.19, 11.36, 3.35, $p<.001$; Form 2 subsample--10.03, 11.47, 3.93, $p<.001$; Form 3 subsample--10.03, 11.15, 3.16, $p<.01$.

-6. Mean ($\pm$ s.e.) CAP scores for females and males in this sample were unadjusted--20.11 $\pm$ .29, 21.63 $\pm$ .28, $p<.0002$; adjusted with EG as covariate--20.02 $\pm$ .23, 20.87 $\pm$ .23, $p<.8641$. A similar pattern holds for the project's larger sample including students who did not study proof writing.

-7. The numbers of students with no proofs correct were as follows: Form 1--55 females, 52 males; Form 2--52 females, 53 males; Form 3--91 females, 77 males.

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THE MORE THINGS CHANGE . . .

reprinted from *American Mathematical Monthly* 1915, v.22, p. 140, "Notes and News"
Thanks to Moe Hirsch for bringing this to our attention.

In the February number of *School Review* Mr. J.H. MINNICK of Horace Mann High School, Columbia University, reports on "A comparative study of the mathematical abilities of boys and girls," based upon the work of 150 boys and 243 girls in the Bloomington (Indiana) high school during the four years beginning September, 1906. Their relative achievements in English, history, language and science were also tabulated and certain definite conclusions were reached by the author. Taking into account the whole student body, the girls are the equals of the boys although they do not excel to the same degree in mathematics as in some other subjects, especially in language and English. Among the retarded students, mathematics has given slightly more trouble to girls than to boys; mathematics is evidently a slightly stronger factor in the elimination of girls than of boys. Measured by ability to achieve, mathematics is about as well suited to girls as are history and science.

Further, the records of 191 students who entered the high school during the years 1903-1909 and later studied in Indiana University were considered, this study indicating that while smaller percentages of girls are conditioned and failed, the girls as a group do not maintain their standing in the university quite as well as do the boys.

The most recent study by Benbow and Stanley links maleness, left-handedness, asthma, myopia, and mathematical ability. Pat Kenschaft has forwarded a February, 1984 column by Erma Bombeck, "Male math supremacy just doesn't add up", which addresses the conclusions of this study. Here is a short excerpt:

"Frankly, I am sick to death of men claiming mathematical supremacy over women. Any country that is run by men and has a national deficit of $200 billion doesn't have any reason for throwing hats in the air."

"Add to that the fact that men have not had a balanced budget in this country since Alexander Hamilton and you've got a lot of right-handed men in the wrong places."

ESSAY REVIEW

BLACK MATHEMATICIANS AND THEIR WORKS.
Edited by Virginia K. Newell, Joella H. Gipson, L. Waldo Rich, and Beauregard Stubblefield. Ardmore, PA (Dorrance & Company), 1980. 327 pp. $18.00 (cloth), $12.50 (paper).

A NEGRO HISTORY COMPENDIUM.
By Ethel M. Turner. Cheyney, PA (Cheyney State College), 1971. 74 pp.

Reviewed by Claudia Zaslavsky.

In October of 1982 the United States College Board revealed for the first time that the scores of black high school seniors on the language and mathematics Scholastic Aptitude Tests (SAT) were about 100 points lower than the national norm, on a scale of 200 to 800. The scores of all students rose with family income and parents' educational level, and the gap between the scores of black and white students narrowed as income rose. But the average family income of white families is more than twice that of blacks [Maeroff 1982; Schanberg 1982].

Most authorities now agree that the SAT measures achievement due to education and experience, rather than innate aptitude. The disparity in scores was publicized in order to serve members of minority groups "by demonstrating the need for affirmative action with respect to access to higher education," in the words of George H. Hanford, president of the College Board [*NY Times*, Oct. 5, 1982, A21; see also Clark 1982].

According to the National Assessment of Educational Progress (NAEP) black children lagged further behind as they grew older [Anick et al. 1981]. Although the majority of all seventeen-year-olds had taken over two years of high school mathematics (grade nine and up), the average for black youths was slightly over one year. However, black students, to a greater degree than the national average, indicated that they considered mathematics important and would like to take more courses. (See [Goldman 1980] on the role of teacher expectation in raising the achievement levels of inner city junior high school students.) The authors concluded: "A major goal for the 1980s should be to eliminate the inequities that exist in the mathematics education of minority students."

Black Mathematicians and Their Works seeks to address this goal. This book is the first to focus upon the research of contemporary black mathematicians; a representative sample of articles and a bibliography of additional works are brought together in one accessible volume. These contributions, already noteworthy in themselves, are outstanding in view of the obstacles their authors had to overcome.

In his foreword Wade Ellis, a black mathematician and retired dean of the Rackham School of Graduate Studies of the University of Michigan, expresses the need to counteract the view held by many teachers that blacks are "abysmally and irrevocably hopeless as far as mathematics is concerned" [page ix]. The existence of a sizable body of works in a field they may have considered inaccessible can provide much-needed encouragement to young black students, and these heroic black men and women can serve as inspiration to all young people, regardless of race or sex.

The book is divided into several sections. In the preface we are told how the 62 black mathematicians and mathematics educators represented in the book were chosen--all (save one) had earned their doctorates before 1973 and had responded to a letter eliciting information. The one exception is Benjamin Banneker, a free black born in 1731, astronomer, mathematician, clockmaker, author of many almanacs, and the man largely responsible for carrying out the plans for the construction of the city of Washington, D.C. We learn of many relevant facts, and of several "firsts"--the first black American to earn a Ph.D. degree in pure mathematics (Elbert Frank Cox, from Cornell in 1925); the first black women mathematicians to have earned the Ph.D. degree (Evelyn Boyd Granville, Yale University, and Marjorie

Lee Browne, University of Michigan, both in 1949); and the first black in any field to be elected to membership in the National Academy of Sciences (David Blackwell, 1973).

The bulk of the book consists of 26 research articles, 23 in pure mathematics and 3 in mathematics education, varying in length from 3 to 24 pages. For instance, David Blackwell, professor of statistics at the University of California at Berkeley and author of over 60 research articles, is represented by "On a Class of Probability Spaces." A. T. Bharucha-Reid, formerly graduate dean at Wayne State University, with an impressive list of articles and books to his credit, submitted "Markov Branching Processes and Semi-groups of Operators." Marjorie Lee Browne's contribution is "A Note on the Classical Groups." Two of the authors, Joella H. Gipson and Beauregard Stubblefield, are represented, respectively, by "Use of the Environment and Discovery in Teaching Decimals to Second Grade Children" and "Lower Bounds for Odd Perfect Numbers (Beyond the Googol)." All three members of the editorial advisory board contributed articles: "Competencies in Mathematics of Certain Prospective Elementary School Teachers," by Edward M. Carroll, professor of mathematics education at New York University; "Fundamental Regions in S_6 for the Simple Quaternary G_{60}," by Walter R. Talbot, mathematics chairman at Morgan State College until his death in 1977; and "Minimum Mass Thin Fins for Space Radiators," by J. Ernest Wilkins, Jr., then Distinguished Professor of Applied Mathematical Physics at Howard University. Other titles will be mentioned in the course of this review.

The biographical index contains data on the 62 mathematicians and mathematics educators, of the type included in a résumé. Yet a great deal of interesting information can be gleaned from these pages. For example, Lillian K. Bradley was the first black woman to receive any type of doctorate from the University of Texas, in 1960. Now associate professor of mathematics at Texas Southern University (a predominantly black institution), she is represented in this volume by "The Relationship between the Performance of the Texas Southern University Freshmen on the Mathematics Placement Test and their High School Mathematics Background." J. Ernest Wilkins earned his Ph.D. degree in mathematics from the University of Chicago at the age of eighteen. Subsequently he received degrees in mechanical engineering, worked in a variety of fields in applied mathematics, and was elected a Fellow of the American Association for the Advancement of Science, the American Nuclear Society, and the National Academy of Engineering Science. The titles of his research articles fill several pages.

Many of these mathematicians have won election to Sigma Xi, Phi Beta Kappa, Pi Mu Epsilon, and other honor societies. They are active in many organizations. Some are officers of the National Association of Mathematicians, an organization of blacks. Others are department chairs, deans, and presidents of their colleges.

Three appendices and a bibliography complete the volume. Appendix 1 contains statistics on the universities at which the 62 blacks received their doctoral degrees. University of Michigan heads the list with eight; its popularity may have been due to its low fees, its proximity to Detroit, a large urban center, and even more, to the encouragement of professors like Raymond L. Wilder. Also noted are the universities at which the mathematicians are employed. Two-thirds of the 52 academics in this survey are at predominantly black colleges and universities, while all but two of the others are at state universities.

Appendix 2, twenty pages in length, contains the most revealing information, and, indeed, it deserves a more prominent position in the volume. Here are documents, articles, and letters written between 1951 and 1954 on the subject of discriminatory practices. Black mathematicians were refused places at banquets and other social affairs of the mathematical societies, housing was not provided for blacks who attended meetings, and, in general, their participation in the life of the societies was discouraged, particularly by academies and institutions in the South. For example, a Tuskegee Institute faculty member attending a meeting in 1951 at the Alabama Polytechnic Institute had to eat by himself. When he inquired at the registration desk about the Social Hour listed in the program, he was told that "technically" he could attend, but that he "probably would not want to do so, as it was being held in one of the girls' dormitories" [page 313]. Since most black academics were employed (by predominantly black colleges) in the South, these practices effectively excluded blacks from membership.

In 1951 the Fisk University mathematics department, led by its chairman Lee Lorch, a white mathematician, initiated a vigorous campaign urging the Mathematical Society to adopt bylaws guaranteeing "explicit and effective protection of the rights of all members to participate fully, freely, and equally in the affairs of the organizations without regard to race, creed or color" [page 307]. In response to such pressure, the MAA Board of Governors, at its September meeting of 1951, affirmed its intention to eliminate discrimination, but left the implementation of the resolution to each section. But in 1954 Lorch noted in a letter to Marjorie L. Browne that "the situation is still far from satisfactory" [page 318]. (Note: At its Summer meeting in 1975 the AMS Council at last passed the following resolution: The AMS shall not hold meetings at hotels or other places where facilities are administered or designated in a discriminatory fashion.)

It was not until about 1969 that blacks began to participate to any great extent in the affairs of the MAA and the AMS. Dr. Talbot attributed the breakthrough in part to a Mathematics Curriculum Conference (1969) involving faculty of the Traditionally Black Institutions (TBI) and supported by the Ford Foundation. He wrote: "That conference was significant because it provided the first realistic opportunity for black Ph.D.'s in mathematics to meet each other, and in some cases to discover each other's existence, and it provided an opportunity for persons already on the national mathematics scene to learn of the existence of these persons in the TBI" [page 324]. At about that time, faculty members of the 109 TBI formed the National Association of Mathematicians (NAM), which has served as a caucus to get blacks into leading positions in the academic societies and has organized programs open to all. Blackwell, Wilkins, and James Donaldson, chairman of the mathematics department at Howard University, became the first (and only) blacks to serve on the Board of Governors of the AMS [personal conversations]. Unfortunately the book gives no information about the formation and the activities of the NAM.

How such discriminatory practices destroyed the creativity of at least one mathematician, William W. Schiefflin Claytor (1908-1967), is told by his friend Walter Talbot. The refusal of both the University of Michigan and Princeton University to employ him because of his skin color "was one of the main chilling, if not killing, points in the research career of a brilliant mathematician" [page 321]. Claytor's résumé lists only his schooling and two articles, published in the *Annals of Mathematics* in 1934 and 1937. The second article, "Peanian Continua Not Imbeddable in a Spherical Surface," is reproduced in this book. Tributes by Wilder, Kuratowski, and others, as well as further details about the lives of both Claytor and Talbot, appear in the NAM Proceedings [National Association of Mathematicians, 1980].

Appendix 2 concludes with Talbot's own autobiographical sketch, already quoted above. His parents and grandparents had attained their education in spite of limited opportunities for formal schooling. Very important in his career was the encouragement of his professors at the University of Pittsburgh, who made sure that he was elected to Sigma Xi and Phi Beta Kappa. Talbot makes a significant comment on the low research output of many black mathematicians: "As for research, very little comes from any of the small colleges, and the TBIs are no exceptions" [page 324].

Many of the vital factors needed to persuade blacks to continue in mathematics are summarized in Talbot's sketch, including role models, encouragement, and government and foundation support. Revealed, too, are some of the difficulties that these black mathematicians have faced and overcome. One wishes for more such autobiographical information.

Other works about black mathematicians are worth noting. Several books deal with the life of Benjamin Banneker [Bedini 1972]; more popular are [Graham 1949] and [Haber 1970]. *Blacks in Science: Ancient and Modern*, designed for classroom use, covers the wide span from ancient Africa to space technology [Van Sertima 1983].

Ethel M. Turner, chair of the department of mathematics at Cheyney State College, Pennsylvania, is the author of a closely packed, well-researched book: *A Negro History Compendium*. She has recorded the achievements of black people as far back as ancient Egypt, and gives special attention to the accomplishments of Afro-Americans prominent in many fields, with emphasis on mathematics and scientific invention. Many of the names mentioned also appear in *Black Mathematicians and Their Works*, and others include the 18th-century slave Thomas Fuller, known as the "Virginia Calculator"; the mathematician Charles Reason, the first black to teach in a white college (1840-1852); and the actuary and medical doctor James McCune Smith, a leading member of the American Statistics Institute in the mid-19th century. Edward Alexander Bouchet was the first black to earn a Ph.D. degree in the United States (Yale, 1876), with a dissertation in physics. He used his talents to teach at the Institute for Colored Youth in Philadelphia, as had Charles Reason before him.

Her list of mathematics textbooks by black authors includes Robert T. Brown's 1919 publication on non-Euclidean geometry, hyperspace, and space curvature. She lists about 150 "Negroes Holding Earned Doctoral Degrees in Mathematics"--both pure and applied mathematics and mathematical education--and 600 with doctorates in other fields. In particular, Dr. Turner faults Booker T. Washington for failing to recognize the importance of mathematics in the industrial training of black youths. Throughout the book she urges her readers to take pride in their heritage and to study as much mathematics as possible, as does S. A. Anderson in his article in *Black Scholar* [Anderson 1970].

Omitted from Turner's book, however, are the achievements of Kelly Miller, the son of a slave. In 1887 he entered Johns Hopkins University to pursue graduate studies in mathematics, astronomy, and physics, but financial problems prevented his completing the requirements for the doctorate. He taught mathematics and became an administrator at Howard University and elsewhere [Morgan 1981].

The production of both *A Negro History Compendium* and *Black Mathematicians and Their Works* suffers from a lack of financial resources. Dr. Turner, author of the *Compendium*, was of necessity also the publisher. Proper funding would have enabled the authors of *Black Mathematicians* to overcome many of the problems they encountered in producing this important work--inadequate professional assistance for research, writing, and editing; failure to include a number of black mathematicians; difficulty in finding a publisher; and the seven-year interval from the initiation of the project until final publication of the book.

Fortunately, the autobiographical information that one misses in these two books is available from several black women who have earned doctoral degrees in pure mathematics. Vivienne Malone Mayes, professor of mathematics at Baylor University, spoke at the 1975 summer meeting of the Association for Women in Mathematics (AWM) [Mayes 1975]. She is represented in *Black Mathematicians and Their Works* by "Some Steady State Properties of ($\int_0^x f(t)dt)/f(x)$," reprinted from the *Proceedings of the American Mathematical Society*. In January 1978, under AWM sponsorship, Professor Patricia C. Kenschaft of Montclair State College chaired a panel at which several black women mathematicians spoke [Kenschaft 1978, 1980a]. She subsequently published an article about 21 black women mathematicians based on both the AWM talks and personal interviews [Kenschaft 1981]. In a later reprint she added a note about five more women [Kenschaft 1981, 1982], and has since prepared an article on black men and women mathematicians [Kenschaft, to appear]. The following information about black women in mathematics comes from Kenschaft's 1981 article, unless otherwise indicated.

The theme of discrimination for reasons of race and sex runs through the lives of most of these women. For example, in 1950 Evelyn Boyd Granville applied for an academic position after having earned a Ph.D. at Yale and completing a year of post-doctoral research. Many years later Kenschaft learned that when the hiring committee at one institution "discovered she [Granville] was Black, they merely laughed at her application and never considered her for the job." In the recent book *Women, Numbers and Dreams*, Granville's story is told in a form suitable for young people [Perl & Manning 1982, 134-147].

Vivienne M. Mayes was a student at Fisk while Granville was on the faculty. Most of the students were girls in the upper-level mathematics classes at Fisk. She found an entirely different atmosphere at the University of Texas in the mid-1960s. As the only black and the only woman in the graduate program in mathematics, she was completely ignored; "my mathematical isolation was complete." She could not become a teaching assistant because she was black, and was even barred from attending some classes [Mayes 1975].

Cuban-born Argelia Velez-Rodriguez, who received her doctorate in mathematics from the University of Havana in 1960, came to the United States in 1962. "She had been free of racism and sexism in Cuba, but was soon made keenly aware of the tension and pressure they caused in this country." She has taught in several colleges, and at the time of Kenschaft's article [1981] was program director of the Minorities Institutions Science Improvement Program of the Department of Education.

Eleanor Green Dawley Jones, now a professor at Norfolk State College, was prevented by the segregation laws of the state of Virginia from pursuing doctoral studies in that state, but was granted tuition and travel costs to study out of the state. While supporting her two small children, she earned her doctoral degree at Syracuse University in 1966. Her paper "A Note on Abelian p-Groups and Their Endomorphism Rings" appears in *Black Mathematicians and Their Works*.

Mayes describes the segregated schools of the South as "strictly separate and strictly unequal." Elayne Arrington-Idowu grew up black and female in the North, near Pittsburgh. Although she finished first in her class in an integrated high school, she was not allowed to give the valedictory address. A scholarship she had won to attend the University of Pittsburgh was withdrawn, in this case because she was female. She must derive great satisfaction now from the fact that she is a faculty member at that university.

Discrimination continues, even today, as Kenschaft writes:

> *Some of these women feel that the educational hurdles for Blacks are worse now than a decade ago, especially in the large Northern cities. This means that although large numbers of children are responding with interest to the increased publicity given to the sciences, the lack of quality education at the primary and secondary levels is preventing them from fulfilling their scientific ambitions.*
>
> *The results of past discrimination remain; these include, but are by no means limited to, poorer schools in predominantly Black neighborhoods, the need of young educated Black people to support younger students in their own families, and extra administrative duties devolving on those from underrepresented groups in the mathematical community. Often Blacks and women feel a responsibility to help others in their own groups, which takes time and energy that would otherwise be used in vigorously pursuing their own professional careers.* [Kenschaft 1981, 603]

The heavy load borne by the faculty of most predominantly black institutions leaves little time for creative work. For example, during the thirty years (1949-1979) that Marjorie Lee Browne was employed at North Carolina Central University, she taught 15 hours a week at both the undergraduate and graduate levels and was department chair for 20 years. Her summers were occupied with courses for secondary teachers, for which she wrote four sets of lecture notes. She served with the National Science Foundation and the Ford Foundation and won several grants for postdoctoral study [Kenschaft 1980b].

The importance of black role models and of encouragement by both black and white instructors cannot be overemphasized. While at Howard University, Eleanor Jones was inspired by Elbert Cox (the first black Ph.D. in pure mathematics) and by other black men with doctorates. Marjorie Lee Browne was directly responsible for

Geraldine Darden's pursuit of higher degrees. Later, as head of the mathematics department of Hampton Institute, Darden employed every possible means to prepare her students for mathematical careers. These instances can be multiplied many times over.

Lee Lorch, head of the Fisk mathematics department from 1950 to 1955, "influenced one-fourth of [his students] to pursue and earn the master's degree in pure mathematics. Moreover, one-tenth of the students continued to the doctorate. Each known doctoral recipient credits Lee Lorch as the greatest influence in his choice of career" [Mayes 1976]. So far as I can ascertain, the only Fisk graduates ever to get Ph.D.'s in mathematics were those who did their undergraduate work with him [personal conversation]. Three of the women discussed in Kenschaft's article (Falconer, Hewitt, and Mayes) were Lorch's students at Fisk. Kenschaft adds: "One might sadly wonder if proportionately more Black women (15 of them) might have received doctorates in mathematics by now if Lorch had been permitted to spend the past 25 years at Fisk." His warm concern and vigorous activity for the welfare of black people, which he believes to have been essential in establishing the rapport and self-confidence these students needed in order to achieve as they did, prompted an attack by the Congressional Committee on Un-American Activities, following which the predominantly white Board of Trustees of Fisk University dismissed him in 1955, without charges or trial [see Kenschaft 1981 and Mayes 1976 for further details].

Government regulation is crucial in guaranteeing job opportunities and equitable conditions of work. Mayes stated: "An additional safeguard of my welfare has been yearly visits by representatives of the government [Department of Health, Education, and Welfare]. They have checked salaries and promotions to determine if I was being subjected to any discrimination" [Mayes 1975]. Recently the visits have stopped, and although she herself is a full professor with tenure, she feels that government inspection is necessary to safeguard the welfare of blacks and women on campus without such protections [personal conversation]. Granville "hopes that the government will continue to pressure industry to hire Blacks and other minorities. She is concerned that present government policy will weaken the gains that were made in the 1970s, and that Blacks and other minorities will again be rejected when they apply for good jobs" [Perl & Manning, 1982, 145-146].

Unfortunately, her fears are well founded. With the current cutbacks in funding for enforcement agencies, discrimination is once again rearing its ugly head. Official unemployment figures for blacks are twice those for whites, while over half of all young black people seeking work are jobless, a most chilling factor to a young black American planning his or her future career. This situation surely invites disaster, and calls for a massive effort for change on the part of thoughtful people [Clark 1982].

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