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ABSTRACT

The following questions are addressed: (1) Are there sex differences in achievement, either in entering knowledge of geometry in the fall, or in achievement in acquiring standard geometry content by year's end? (2) Are there sex differences in the performance of students on the van Hiele test, either at the beginning or end of the year? and (3) Are sex differences exhibited in the writing of geometry proofs? Subjects were 1392 boys and 1307 girls in 99 classes, grades seven through twelve, from 13 schools located in 5 states. Schools were chosen to include a variety of regions and socioeconomic groups, and the population included substantial black, Hispanic, and Oriental minorities. A proof-writing sample consisted of 1520 students in 74 classes which had studied proof and whose teachers agreed to participate. Results indicated that boys were superior in content knowledge upon entering the geometry courses. Adjusting scores for this entering knowledge led to observation that girls were equally able to learn both geometry content and exhibit higher cognitive reasoning required in writing geometry proofs. Therefore, no sex differences in geometry achievement were found. (MP)

SEX DIFFERENCES
IN GEOMETRY ACHIEVEMENT

by

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Advisory Board: Charles Allen, Los Angeles (CA) Public Schools
Mary Grace Kantowski, University of Florida
Sharon Senk, Newton (MA) Public Schools and The University of Chicago
Jane Swafford, Northern Michigan University

The CDASSG project was conceived by Zalman Usiskin and Sharon Senk. Coding and scoring of multiple choice tests were done under the direction of Roberta Dees; coding and scoring of proof tests, under the direction of Sharon Senk; data analyses, using Statistical Analysis System programs, were done by Roberta Dees, Sharon Senk, and Zalman Usiskin.

All statements and interpretations in this paper are the author's and do not suggest opinions or policies of anyone else associated with the project or with the National Institute of Education.

SEX DIFFERENCES IN GEOMETRY ACHIEVEMENT

Investigation of sex differences in mathematics achievement has generally indicated that such differences as do exist begin to appear in early adolescence and seem to increase through secondary school. It is known that girls take fewer advanced mathematics courses than boys (Ernest, 1976; Fennema, 1977). Recent research indicates that when boys and girls take a comparable number of courses in mathematics, sex differences in mathematics achievement are negligible (Fennema and Sherman, 1977, 1978; Schonberger, 1978). Specifically, a study of achievement in first year algebra showed no sex-related differences (Swafford, 1981).

However, a study of mathematical reasoning ability, as measured by the mathematics portion of the Scholastic Aptitude Tests, showed large differences in favor of boys (Benbow and Stanley, 1980). The authors discount the influence of differential course taking and favor the hypothesis of superior male mathematical ability, possibly related in turn to greater male spatial ability. However, an analysis (Becker, 1978) of the SAT-M items, with a subset of Benbow and Stanley's sample as subjects, showed that "the commonly offered hypothesis that girls reason more poorly mathematically than boys do because the former handle relationships less well does not hold for seventh-grade girls who score well on a difficult mathematical-reasoning test."[1] Sex differences in spatial visualization skills have not been consistently seen in younger children, but have been reported as more pronounced in favor of boys between upper elementary years and the last year of high school (Maccoby and Jacklin, 1974). In contrast, the Women in Mathematics study (NAEP, 1980) found that on spatial visualization, girls at age 13 did better than boys by 5 percentage points and that girls in twelfth grade did as well as boys. A meta-analysis was done by Hyde (1981), who reviewed the same studies that Maccoby and Jacklin had reviewed. The magnitude of gender differences on verbal ability, quantitative ability, and visual-spatial ability, though "well established," were found to be very small, accounting for no more than 1-5% of the population variance.

Since girls of comparable level seem to achieve as well as boys in the first year algebra course, as mentioned earlier, a logical question concerns the relative achievement of boys and girls in geometry, usually the next course in the college preparatory sequence. This seems especially appropriate since spatial ability often has been suggested as a factor in success in geometry. (An early geometry study (Werdelin, 1961) reported that girls did better at geometry proofs than boys, but otherwise little information is available.) Furthermore, the sex differentiation of mathematics course-taking seems to occur after the geometry course has been completed, according to a study in Wisconsin (Fennema, 1977). Thus, the geometry course represents an opportunity to determine whether this course marks the origin of such sex differences in mathematics achievement as appear in older students. This paper reports the examination of data from a nationwide study to see whether sex differences exist in geometry achievement.

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[1] Stanley, J.C., April 27, 1978. In transmittal letter of master's paper (Becker, 1978).

This report addresses the following questions:

1) Are there sex differences in achievement, either in entering knowledge of geometry in the fall, or in achievement in acquiring standard geometry content by the end of the year?

2) Are there sex differences in the performance of students on the van Hiele test, either at the beginning of the year or at the end?

3) Are sex differences exhibited in the writing of geometry proofs?

Method

Subjects

Subjects consisted of all geometry students in each of 13 schools in 5 states, chosen to include a variety of schools, regions, and socioeconomic groups. The population included substantial Black, Oriental and Hispanic minorities. There were 1392 boys and 1307 girls in 99 classes, in grades 7 through 12. At the time of the study, 60% were in grade 10 Students were aged 12 through 20, with the median age 16 years 3 months, and 83% aged 14-17.

The sex ratio of the total sample was within 1/2% of the sex ratios in both national and school populations at age 14-17.[1] The sex ratios of 6 of the schools, including the 2 largest, were within 2% of the national ratios. In two schools only one-third of the geometry students were girls; in three schools over 60% were girls. The percentage of girls in the individual classes ranged from 8% to 72%. Three classes consisted of more than two-thirds girls; 62 classes contained from 40 to 60% girls; and in 11 classes, less than one-third of the students were girls.

Procedure

In fall, 1980, students were given two instruments designed by the project staff: a test designed to identify their van Hiele level (Hoffer, 1979, 1981) and a test of standard geometry content, called the Entering Geometry (EG) test. In spring, 1981, students were given the same van Hiele test and a standardized geometry achievement test, the Comprehensive Achievement Program (CAP) test (Scott Foresman, 1980). A test of proof-writing achievement, devised by the project staff, was also given to students in 74 classes whose teachers agreed to participate. Pilot studies of the three tests developed by the project indicated that enough time was allowed for completion of the tests. The tests were administered during the regular school day by the geometry teachers and monitored by representatives of the project.

Results

The data on each individual test, such as comparison of means by sex or item analysis, are taken from the largest possible sample, that is, the entire

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[1]Statistical Abstract of the U.S. (U.S. Department of Commerce, Washington, D.C., 1980), p. 145.

group who took that test. These were all the students who were present that day in all the geometry classes in the school (including non-proof classes, such as "Essential Geometry"). For analyses that involved more than one of the four multiple choice tests, the data reported are from the group of students who took all four (hereafter called ALL4).

Knowledge of Geometry Content

The Entering Geometry (EG) test was a 19-item, 25-minute, multiple choice test of geometry terminology and facts. On this test, boys were about one item ahead of girls at the beginning of the school year, a significant difference ($t=5.90$, $p < 0.001$). Means and standard deviations by sex are given in Table 1. On the items of the EG test, the boys were slightly favored (from 1 to 9.3%) on all but one of the items. Given in Figure 1, with the percentages of boys and girls making each response, are: A, the easiest item; B, the most difficult item, and one of the two that favored the boys most; C, the other item that favored boys most, and D, the item that did not favor the boys.

At the end of the school year, students were given a 40-item, 40-minute standardized test of geometry content (CAP). Table 2 gives the means of the CAP test. The boys were still about one item ahead of the girls in the total sample; the difference is significant, though not as large ($t=3.10$, $p < .001$). However, an analysis of covariance, adjusting for entering knowledge of geometry, shows no significant sex effect on performance on the CAP test. The means and adjusted means on CAP (ALL4 sample) are shown in Table 3.

By the end of the year, the boys' advantage on geometry content had decreased, as previously mentioned. On six items of the CAP test there was less than 1% difference between the percentage of boys and girls correct, and on 21 other items, less than 5% difference. Of the remaining items, 11 favored the boys (from 5 to 11%) and 2 favored the girls (from 5 to 10.7%). Figure 2 shows A, the easiest item; B, the most difficult item; C, the item that favored the boys most, and D, the item that favored the girls most. Included are the percentages correct for the total sample and for the population on which the CAP test was standardized (Scott Foresman, 1980).

The schools in the sample exhibited wide differences, with school means on the EG test ranging from 6.08 to 13.57, and on the CAP, from 12.63 to 23.22. Therefore a two-way analysis of variance was done on both the EG and CAP tests with school and sex used as sources of variance. Results are shown in Table 4. The F-ratio for sex on the CAP test would also be significant at a lesser criterion ($p < .05$). The lack of significant school by sex interaction indicates that achievement for the two groups is relatively stable across schools despite the differences between schools.

Table 5 shows the means and standard deviations by school and by sex of the EG and CAP tests. In six of the schools there was a significant sex difference favoring the boys on the EG test, but the boys were significantly better in only 3 schools in the CAP test.

Table 1

Means and Standard Deviations

Entering Geometry Test

Sex	n	$\bar{X}$	S.D.
F	1183	9.25*	3.8
M	1228	10.17	3.9

*Significant t-value, $p < .001$

Table 2

Means and Standard Deviations

on Comprehensive Achievement Program Test

Sex	n	$\bar{X}$	S.D.
F	962	18.28*	7.0
M	1053	19.28	7.5

*Significant t-value, $p < .001$

Table 3

Means, Adjusted Means[1], and Standard Errors

on Comprehensive Achievement Program Test, ALL4 Sample

Sex	N	$\bar{X}$	S.E.	$\bar{X}$(Adjusted)[1]	S.E.
F	762	18.75*	.25	19.40	.19
M	834	19.92	.25	19.32	.20

*Significant t-value, $p < .001$

[1]Adjusted for entering knowledge of geometry

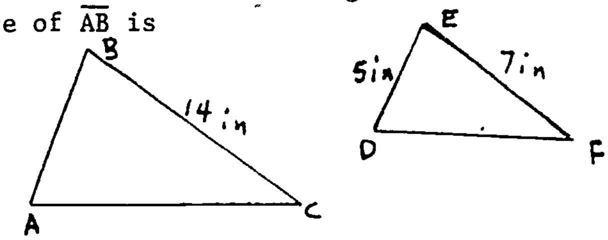
Figure 1

Four Items from the Entering Geometry Test

Percentage[1] choosing each response

A. Triangle ABC is similar to triangle DEF.
The measure of $\overline{AB}$ is

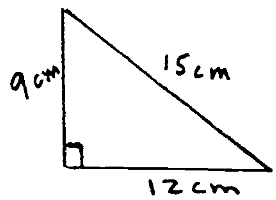
(a) 10 in
(b) 11 in
(c) 12 in
(d) 13 in
(e) 15 in



	M	F
*a.	78.3	71.5
b.	3.8	3.9
c.	12.5	18.8
d.	2.4	2.4
e.	2.0	1.7

B. The area of the triangle shown is

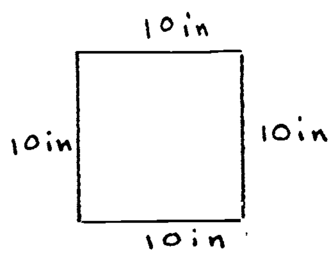
(a) 36 sq cm
(b) 54 sq cm
(c) 72 sq cm
(d) 108 sq cm
(e) 1620 sq cm



	M	F
a.	39.6	46.7
*b.	29.1	19.8
c.	5.9	4.7
d.	9.8	12.2
e.	14.9	15.1

C. The area of the square shown is

(a) 20 sq in
(b) 40 sq in
(c) 40 inches
(d) 100 sq in
(e) 100 inches



	M	F
a.	3.3	1.5
b.	18.5	20.9
c.	13.1	16.2
*d.	56.6	47.3
e.	7.6	12.9

D. If two figures are similar but not congruent then they

(a) have congruent bases and congruent altitudes
(b) have the same height
(c) both have horizontal bases
(d) have a different shape but the same size
(e) have a different size but the same shape

	M	F
a.	5.5	5.0
b.	4.5	3.6
c.	8.0	5.7
d.	15.3	16.1
*e.	65.4	67.1

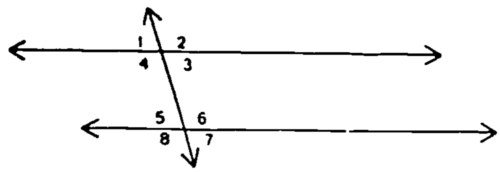
*Correct response

[1] Based on 1230 males and 1188 females

Figure 2

Four Items from the CAP Test
with Percentage[1] Choosing Each Response

A. In the figure below, which angles are vertical angles?



A. ∠5 and ∠7
B. ∠5 and ∠6
C. ∠5 and ∠3
D. ∠5 and ∠4
E. ∠5 and ∠1

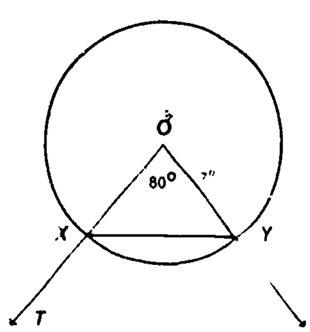
	Sample			
	M	F	Total Sample	Standard
*A.	81.3	77.2	79.3	84
B.	4.3	9.9		
C.	4.1	5.3		
D.	1.9	1.3		
E.	8.1	6.1		

B. A woman travels 2 miles north, 3 miles east, 4 miles north, and 5 miles east. How far would she have traveled if she were able to go in a straight line from her starting point to her destination?

A. $\sqrt{6} + \sqrt{8}$ miles
B. $3\sqrt{6}$ miles
C. $\sqrt{13} + \sqrt{41}$ miles
D. 10 miles
E. 14 miles

	M	F	Total Sample	Standard
A.	11.0	9.6		
B.	10.4	8.6		
C.	17.6	13.8		
*D.	28.9	23.5	26.4	24
E.	18.2	26.3		

C. Two radii in a circle of radius 7″ make an angle of 80°. Chord $\overline{XY}$ connects the endpoints of the radii. How big is $\angle TXY$?

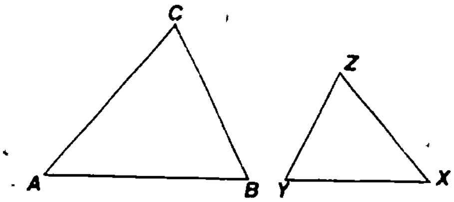


A. 50°
B. 80°
C. 100
D. 130
E. 180

	M	F	Total Sample	Standard
A.	4.8	7.0		
B.	10.2	11.5		
C.	15.8	20.0		
*D.	60.1	49.2	54.9	53
E.	3.1	5.1		

Figure 2 (Continued)

D. In the figure below, $CA = \frac{5}{7} \cdot AB$ and $ZX = \frac{5}{7} \cdot YX$. $\angle A \cong \angle X$. Then $\triangle ABC \sim \triangle XYZ$ because of the similarity theorem



A. HL (hypotenuse-leg).
B. AA (angle-angle).
C. ASA (angle-side-angle).
D. SAS (side-angle-side).
E. SSS (side-side-side).

A.	12.8	11.5		
B.	16.7	12.0		
C.	12.7	9.3		
*D.	40.1	50.7	45.2	46
E.	7.8	4.8		

*Correct response

[1]Percentages based on 1051 males and 964 females.
[2]Reported by Scott Foresman (1980)

Table 4

F-Ratios for ANOVA
School x Sex

Test	School	Sex	School x Sex
Entering Geometry Test	23.25*	24.65*	.56
CAP Test	22.00*	4.78	.60

*p < .001

Table 6

Mean Subscores and Standard Deviations on van Hiele Test

Subtest[1]	Sample	N	Mean	S.D.	N	Mean	S.D.
Level I	M	1200	3.87*	1.03	1071	4.34*	.92
	F	1161	3.74	1.03	987	4.13	.98
Level II	M		2.47	1.33		3.67*	1.31
	F		2.42	1.31		3.45	1.34
Level III	M		1.63	1.23		2.79*	1.44
	F		1.58	1.16		2.61	1.45
Level IV	M		1.21	1.01		1.78	1.24
	F		1.18	.98		1.70	1.18
Level V	M		1.46*	1.05		1.94	1.23
	F		1.64	1.07		2.01	1.19

*Significant t-value, p < 0.05.

[1]Each subtest contained 5 items, for a possible score of 5.

Table 5

Means and Standard Deviation for Content Tests by School and Sex

School	Sex	Enter. Geometry (Fall) N	$\bar{X}$	SD	CAP (Spring) N	$\bar{X}$	SD
Total	F	1183	9.24*	3.8	962	18.28*	7.0
	M	1228	10.17	3.9	1053	19.28	7.5
1	F	58	5.81	2.6	57	11.87*	3.4
	M	35	6.51	3.3	34	13.88	5.2
2	F	174	9.24*	3.6	137	17.70	5.3
	M	165	9.96	3.8	131	18.27	5.7
3	F	57	9.03	3.5	23	15.04*	4.8
	M	59	10.07	3.6	26	18.23	5.2
4	F	20	9.75	3.4	18	16.16	3.4
	M	19	9.37	3.0	16	18.18	6.2
5	F	50	8.26*	2.8	44	15.25	5.0
	M	35	9.34	2.9	30	15.93	5.7
6	F	56	9.41*	3.7	51	15.47	5.6
	M	75	10.96	4.2	82	16.31	7.3
7	F	10	10.90	4.2	10	16.80	3.8
	M	19	11.26	4.0	19	17.79	5.2
8	F	118	9.33*	3.4	107	18.21*	4.9
	M	169	10.18	3.5	148	19.82	5.5
9	F	342	9.59	4.1	276	21.31	8.7
	M	349	9.93	4.1	307	21.31	9.1
10	F	100	8.58	3.1	82	15.96	5.5
	M	65	9.23	3.3	58	15.88	5.8
11	F	64	12.78*	3.4	43	22.07	7.3
	M	75	14.24	3.1	54	24.13	6.4
12	F	21	9.90	2.3	18	19.33	4.4
	M	46	11.04	3.1	45	19.91	5.5
13	F	113	8.58*	3.7	96	18.04	6.3
	M	117	9.58	3.8	103	18.60	7.6

*Significant t-value, $p < 0.05$

The Van Hiele Test

The van Hiele (VH) test consisted of five sub-tests, each containing five items. The five subscores were used to determine whether the student could be classified as being "at a given van Hiele level." The same test was given in the fall and in the spring. Table 6 shows the mean raw subscores and standard deviations by sex on both administrations of the VH test. The validity and significance of the van Hiele levels are being discussed by Zalman Usiskin in another presentation at this meeting; therefore, this analysis will be confined to performance on the subtests by sex. In the fall, the boys were significantly ahead of the girls on Level I questions; there were no differences in Levels II, III and IV; and the girls were significantly better in Level V questions.

The majority of students did move up a level during the year, about a fourth moving up two or more levels. An item analysis shows that on each subtest, there was an overall tendency for boys to slightly increase their advantage or decrease their disadvantage by the end of the year. (This would also be indicated by the total scores if the VH test were treated as a 25-item test.)

Figure 3 shows one item from each of the levels, with percentages by sex for each response. Item A, from Level I, was the easiest item in both fall and spring. Item B, from Level II, favored boys most in the spring. Item C, from Level III, was the most difficult item in the fall, and item D, from Level IV, was the most difficult item in the spring. Item E, from Level V, favored the girls most in the fall.

The VH test was constructed to test for the five van Hiele levels, and thus was considered by the project as five subtests. If, however, it were considered as a single, 25-item test, then the means of the fall VH test total score (VHFTOT) are slightly, but not significantly, higher for the boys. However, an analysis of covariance, with the Entering Geometry scores as covariate, shows that when VHFTOT is adjusted for entering knowledge, the girls' means are significantly higher. By the end of the year, as indicated by the item analysis, the boys had improved their standing relative to the girls'. Again, an analysis of covariance on VH spring total scores (VHSTOT), adjusting for entering geometry knowledge, shows no sex difference. The means and adjusted means by sex for VHFTOT and VHSTOT are given in Table 7.

Proof-Writing Achievement

The total proof sample consisted of 1520 students in 74 classes which had studied proof and whose teachers agreed to participate.

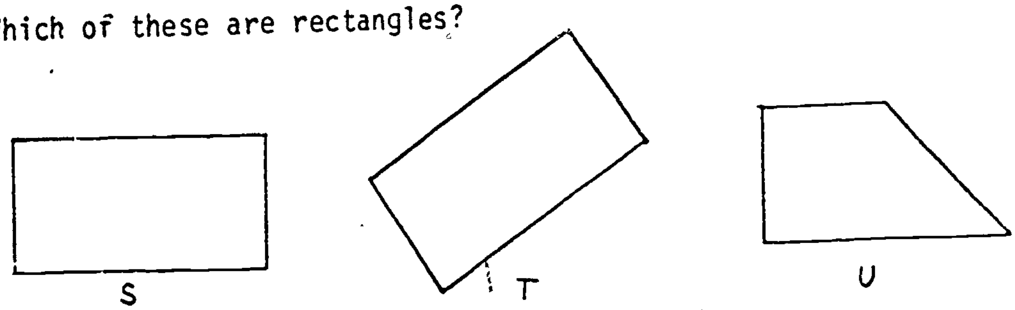
During a five-day period in the last month of the school year, the students were given the CAP test, the VH test and the proof test. Three forms of the proof test were developed by project personnel. Each form contained 6 items: 1 fill-in of statements and/or reasons in a proof; 1 translation of a verbal statement into an appropriate figure, with "given" and "to prove;" and 4 full proofs. Items were similar to standard textbook exercises on congruent and similar triangles, parallel lines and quadrilaterals.

The proof tests were graded blindly by 8 experienced high school teachers, 2 women and 6 men, on a scale of 0 to 4. Two measures of proof-writing achievement were analyzed. The first, called "Sum Score," was the customary sum of the item scores, with a maximum possible score of 24. The second, called "number of Proofs Correct," was the number of full proof items on which the student scored either 3 or 4 (maximum Proofs Correct is 4).

Figure 3

Five Items from van Hiele Test
with Percentage Choosing Each Response

A. Which of these are rectangles?



(A) S only

(B) T only

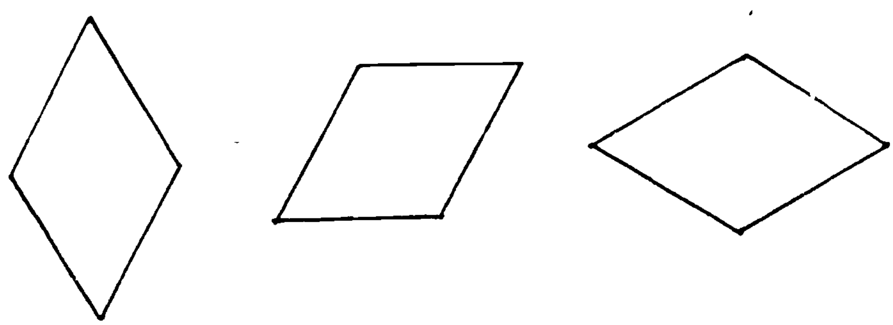
(C) S and T only

(D) S and U only

(E) All are rectangles.

B. A <u>rhombus</u> is a 4-sided figure with all sides of the same length.

Here are three examples.



Which of (A)-(D) is <u>not</u> true in every rhombus?

(A) The two diagonals have the same length.

(B) Each diagonal bisects two angles of the rhombus.

(C) The two diagonals are perpendicular.

(D) The opposite angles have the same measure.

(E) All of (A)-(D) are true in every rhombus.

C. Which is true?

(A) All properties of rectangles are properties of all squares.

(B) All properties of squares are properties of all rectangles.

(C) All properties of rectangles are properties of all parallelograms.

(D) All properties of squares are properties of all parallelograms.

(E) None of (A)-(D) is true.

D. Here are three properties of a figure.

Property D: It has diagonals of equal length.

Property S: It is a square.

Property R: It is a rectangle.

Which is true?

(A) D implies S which implies R.

(B) D implies R which implies S.

(C) S implies R which implies D.

(D) R implies D which implies S.

(E) R implies S which implies D.

E. Two geometry books define the word rectangle in different ways. Which is true?

(A) One of the books has an error.

(B) One of the definitions is wrong. There cannot be two different definitions for rectangle.

(C) The rectangles in one of the books must have different properties from those in the other book.

(D) The rectangles in one of the books must have the same properties as those in the other book.

(E) The properties of rectangles in the two books might be different.

Figure 3 (Continued)

		Fall[1] M	Fall[1] F	Spring[2] M	Spring[2] F
A.	A	3.3	3.7	1.3	1.2
	B	1.9	.9	.4	.5
	*C	93.0	93.2	96.9	97.3
	D	.3	.4	.3	.1
	E	1.4	1.7	1.1	.8
B.	*A	40.4	37.1	73.7	64.7
	B	17.1	18.3	6.0	8.4
	C	16.0	14.6	5.7	6.7
	D	7.1	7.9	2.3	4.8
	E	18.8	21.2	12.1	15.0
C.	*A	13.4	11.8	36.2	32.7
	B	14.1	13.9	14.2	17.0
	C	20.2	21.2	14.5	16.5
	D	11.6	14.0	7.2	9.2
	E	40.0	37.9	27.7	24.0
D.	A	30.0	31.5	24.3	22.7
	B	20.6	18.2	21.8	18.9
	*C	19.9	17.1	29.3	28.0
	D	20.5	24.4	15.9	21.0
	E	7.8	6.6	8.3	9.3
E.	A	7.9	3.6	6.3	5.4
	B	11.4	10.5	9.3	9.0
	C	20.5	19.9	21.2	19.7
	D	18.8	12.8	21.8	21.2
	*E	39.7	52.2	40.2	44.3

*Correct response.

[1]Percentages based on 1168 males and 1129 females
[2]Percentages based on 1071 males and 987 females

Table 7

Means and Standard Errors of Total Van Hiele Scores by Sex

	Sex	N	Means	S.E.	Adjusted[1] Means	S.E.
VHFTOT	F	762	10.79	.12	11.06*	.10
	M	834	10.97	.12	10.71	.09
VHSTOT	F	762	14.25*	.15	14.62	.12
	M	834	15.00	.14	14.65	.11

[1]Adjusted for knowledge of entering geometry.

*Significant difference, $p < .01$

Analysis of proof-writing achievement by sex was done by Sharon Senk (Senk and Usiskin, in preparation) and is summarized here. (Other aspects of the proof study are being discussed by Senk in another presentation at this meeting). Results reported are based on 1364 students who took both the EG and the proof test, 690 boys and 674 girls, the sex ratio again being within one-half percent of sex ratios in national and school populations.

Mean scores by sex are reported in Table 8. Raw mean Sum Scores were higher for males on two forms, and for females on the other, but the differences were not significant. Since the boys' mean scores were higher on the Entering Geometry test, the proof Sum Scores were adjusted for EG scores. The adjusted females' mean proof scores, adjusted for EG, were higher than those of the males on all forms, significantly higher on one form.

The mean number of Proofs Correct is higher for the males, significantly higher on one form; however, the scores adjusted for EG favor the females slightly. Thus although girls generally enter the high school geometry course with less knowledge of geometry content, by the end of the year there is no difference between the sexes on total proof performance.

Item analysis reveals no pattern of significant differences. Mean scores were higher for males on 11 items and for females on 7 items. Two of the differences in item means were significant at the .05 level, one favoring males, one favoring females. Figure 4 shows 4 of the 12 complete proofs. Item A was the easiest; B, the hardest; C, the item that most favored the boys; and D, the item that most favored the girls.

Three subsets of high-achieving students were examined. There were 12 girls and 8 boys who were in seventh or eighth grade during the year of the study. No significant differences by sex were found on any of the variables tested in this accelerated group.

The second subset consisted of those in the sample who scored in the top 3% nationwide on the CAP test. There were 89 students, 31 females and 58 males in grades 7 to 10, in this sample. This indicates that significantly more males than females scored at the higher levels on this standardized test. However, proof-writing achievement in this group showed no significant sex differences. Their proof score means are given in Table 9.

The third subset contained the highest scoring students on the proof test. There were 21 students whose Sum Score was 22-24 on Form 1; 21 students with a perfect Sum Score of 24 on Form 2, and 31 students with a perfect Sum Score of 24 on Form 3. This group was balanced, consisting of 37 females and 36 males.

Since there were no consistent patterns of sex differences on the proof test, either in the complete sample of mixed ability students or in three high-achieving subsets, it was concluded that there were no sex differences in geometry proof-writing achievement.

Table 8

Mean Scores and Standard Errors on Proof Tests, by Form

Form	Sex	n	Raw Sum Score (s.e.)	Sum Score adjusted for entering geometry (s.e.)	Raw number of Proofs Correct (s.e.)	Number of Proofs Correct, adjusted for entering geometry (s.e.
1	M	234	12.87 (.42)	12.33 (.36)	1.55 (.08)	1.45 (.07)
	F	219	12.34 (.43)	12.91 (.36)	1.50 (.08)	1.61 (.07)
2	M	240	14.60 (.41)	13.95 (.34)	1.97 (.09)	1.83 (.08)
	F	214	13.93 (.44)	14.65 (.36)	1.72 (.10)	1.88 (.08)
3	M	216	12.82 (.52)	12.18 (.43)*	1.75 (.11)	1.62 (.09)
	F	241	13.05 (.49)	13.63 (.41)	1.64 (.10)	1.75 (.09)

*Difference is significant at the .05 level.

Figure 4

Four Items from Proof Test, with Mean Sum Scores

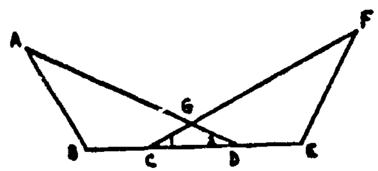
A. **Write this proof in the space provided.**

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

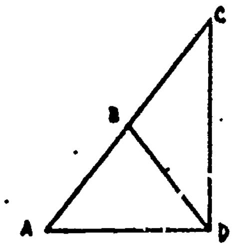
$\angle 1 \cong \angle 2$

$\angle B \cong \angle E$

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



B. **Write this proof in the space provided.**



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

AB = BD.

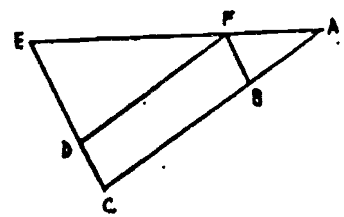
PROVE: $\angle CDA$ is a right angle.

C. **Write this proof in the space provided.**

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

$\triangle FDE \sim \triangle ACE$

PROVE: BCDF is a parallelogram.



D. **Write this proof in the space provided.**

GIVEN: Quadrilateral HIJK

HI = HK

IJ = JK

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

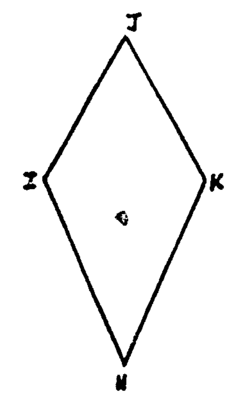


Figure 4 (Continued)

Item Sum Score Means and Standard Errors by Sex

Item	Sex	N	Mean Sum Score	S.E.
A	M	241	3.09	0.10
	F	214	2.98	0.11
B	M	235	0.79	0.07
	F	219	0.83	0.07
C	M	241	1.20	0.10
	F	214	0.84	0.09
D	M	216	2.12	0.13
	F	241	2.27	0.12

Table 9. Achievement for Students in the Top 3% Nationwide on the CAP Standardized Geometry Sample

Form	Sex	n	Mean proof Sum Score	(s.e.)	Mean number of Proofs Correct	(s.e.)
1	F	9	20.33	(.71)	3.11	(.26)
	M	19	20.11	(.41)	2.95	(.16)
2	F	12	22.58	(.57)	3.75	(.13)
	M	25	22.00	(.50)	3.52	(.15)
3	F	10	22.60	(.37)	3.80	(.13)
	M	14	21.93	(.46)	3.57	(.20)

Discussion

Though sex ratios varied in individual schools and classes, the overall sex ratios of the geometry students in the sample very nearly approximated the sex ratios of students nationwide. Therefore, girls tend to take fewer mathematics courses than boys, this trend apparently begins after the geometry course.

Boys enter the geometry course with significantly greater knowledge of geometry content, as tested by a multiple choice test of standard geometry terminology and definitions. The project did not investigate the reasons for the boys' advantage. Some possible factors might include the following:

1) Differential course-taking
In the ninth grade many schools offer home economics and industrial arts, or "shop", as electives. If boys took industrial arts courses in greater numbers than girls, then they may have been more frequently exposed to the definitions of squares, rectangles, etc., and to such concepts as perimeter and area.

2) Part-time jobs, or assistance to parents
It may be that more boys than girls have worked at tasks such as carpentry, surveying, putting up fence, or other tasks which involve the elementary concepts of geometry.

3) Recreational activities, such as sports
It may be that more boys than girls have been involved in leisure-time activities that involve rectangular playing areas or in which angles might be important.

4) High ability boys seem to be more involved than girls in mathematics activities outside of class (participating in mathematics contests, experimenting with computers, etc.).

The van Hiele test was constructed to test for the five developmental levels that are described by van Hiele's theory. Therefore, the project did not consider it as an achievement test. However, an argument could be made that, in spite of efforts to the contrary, the resultant test was content-oriented. If the VH test were merely another test of content, then one might expect a sex bias in favor of the boys as seen on the EG test. This did in fact occur. However, the test is also testing something else besides the content that is covered on the EG test. Whatever the VH test is testing, the boys improved on it during the year.

Concerning achievement in the geometry course, however, the conclusion of this report can be summarized as follows:

The boys were superior in content knowledge upon entering the geometry course. When scores were adjusted for this entering knowledge, girls were equally able to learn geometry content (as measured by the CAP standardized test). More importantly, in spite of the boys' initial advantage, the girls were also equally able to exhibit the higher cognitive reasoning required in writing geometry proofs. Thus, for the high schools in our sample, there were no sex differences in geometry achievement.

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