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The Effect of Sex-Dependent Norms on Aggregated Reading and Mathematics Test Scores

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ABSTRACT. Differences between school reading and mathematics means, rank orderings, and change scores obtained from total-group and sex-dependent norms were examined. Small mean differences were found in approximately 10 percent of the cases, and shifts in rank order were neither widespread nor large. Moreover, the majority of sex-dependent change scores of schools with a 20 percent or greater shift in the proportion of boys over a two-year period were larger than the corresponding total-group values. These findings did not justify the use of sex-dependent norms for such purposes as program evaluations, merit school award programs, and longitudinal comparisons of schools.

Maccoby and Jacklin's The Psychology of Sex Differences (1974) stimulated research activity that has continued unabated into the 1980's. The topic of sex differences, for example, was highlighted at the 1983 annual meeting of the American Psychological Association, and the 1985 ETS Visiting Committee recommended that, as an equity issue in testing, gender differences research should be expanded (Fleming, 1985). Moreover, reviews of sex difference research conducted since 1974 confirm Maccoby and Jacklin's basic conclusion: boys tend to score higher than girls on mathematics tests, while girls tend to score higher than boys on measures of verbal ability.

A substantial body of research has revealed a large discrepancy between the mathematics achievement of boys and girls (Petersen, Crockett, and Tobin - Richards, 1982). Although the mathematics achievement rates of the two sexes are relatively similar through grade five, differences favoring boys begin to appear during the middle school years and continue to increase through the senior high school years (Hilton and Berglund, 1974; Maccoby and Jacklin, 1974; Bank, Biddle, and Good, 1980; Stewart, 1981; Meece, Pearson, Kaczala, Goff, and Futterman, 1982; Levine and Ornstein, 1983).

There appears, however, to be one major exception to the typical pattern of higher male scores in mathematics: some research has shown that girls scored significantly higher than boys in mathematics computations (Armstrong, 1981; Levine and Ornstein, 1983; Randhawa and Hunt, 1984). Girls' superiority in computations also has been shown to hold true across the entire distribution of percentile rank scores (Hieronymus, Lindquist, and Hoover, 1982).

Contrary to the general trend evidenced in mathematics achievement, girls score higher than boys on reading tests. For example, they score higher than boys on measures of prereading skills at the beginning of kindergarten (Scheuneman and Mitchell, 1979). Moreover, a series of studies showed that girls between the ages of six and eight consistently outperformed boys in the same age range on measures of reading achievement (Thompson, 1975). The effect of sex differences, however, apparently disappears by the time adulthood is reached (Herman, 1975; Johnson, 1975; American College Testing Program, 1976a, 1976b). Hogrebe, Nist, and Newman (1984) found that virtually no sex differences remained at the high school level. Bank, Biddle, and Good (1980), and Levine and Ornstein (1983), on the other hand, found that girls read better than boys throughout the high school years.

The purpose of this study was to determine whether disproportionate numbers of boys and girls in a given grade level at various schools might have an inequitable effect on the mean achievement test scores of those schools. Although the effect of socio-economic variables on aggregated test scores has received considerable attention (e.g., Abalos, Jolly, and Johnson, 1984), very little, if any, effort has been expended to study the effect of disproportionate numbers of boys and girls on such scores. Given the frequent use of these scores in program evaluations, merit school award programs, district rankings, and longitudinal comparisons of schools, this issue warrants investigation.

Procedures

Setting

The student population of the Palm Beach County Schools reflects a cross-section of socio-economic backgrounds, ranging from the Palm Beach resort environment to that of the migrant farm worker. The racial composition of the district is: 63 percent white, 28 percent black, 8 percent Hispanic, and 1 percent Haitian. Thirty-eight percent of the students receive free or reduced-price lunches. There are approximately 6,000 students at each grade level, and the proportion of boys and girls in the system is virtually identical.

Preliminary Study

A preliminary study was conducted to determine whether there were sex-related differences between the verbal and quantitative performance of boys and girls enrolled in the district schools. The data source was the 1984 Normal Curve Equivalent (NCE) scores of students on the following Stanford Achievement Test, Seventh Edition (SAT/7), subtests: Word Study Skills, Reading Comprehension, Total Reading, Concepts of Number, Mathematics Computation, Mathematics Applications, and Total Mathematics. A brief description of the SAT/7 subtests used in the preliminary study follows:

Word Study Skills (grades 2-6). The Word Study Skills subtest has two major emphases: structural analysis and phonetic analysis. Structural analysis has to do with the decoding of words through the analysis of word parts, and phonetic analysis is concerned with the relationships between sounds and letters.

Reading Comprehension (grades 2-9). The SAT/7 measures reading comprehension as it relates to the type of material read and the particular questions asked. For grade two, the subtest begins with three short passages presented in a multiple - choice, modified cloze format, which enables students to respond in a way that approximates the reading process. The rest of the subtest consists of complete passages with accompanying questions.

For grades 3-9, the subtest contains three types of reading passages: passages that are typical of the kinds of material found in grade-appropriate textbooks (textual reading); passages that reflect the printed material one finds in daily life (functional reading); and passages that represent the kinds of material one reads for enjoyment (recreational reading). The questions that follow each passage are designed to tap literal and inferential comprehension skills. Literal comprehension refers to students' ability to understand what has been explicitly stated in the passage; inferential comprehension refers to students' ability to make inferences, draw conclusions, and predict outcomes.

<u>Concepts of Number (grades 2-9)</u>. This subtest assesses students' ability to perform the basic number computations appropriate for given grade levels.

<u>Mathematics Applications (grades 2-9)</u>. This subtest provides information about students' ability to apply the number concepts and computation skills they have learned to problem-solving situations.

The SPSS BREAKDOWN computer program was used to perform one-way analyses of variance on the applicable SAT/7 NCE subtest means for boys and girls at grades 2-9.

Results

The results of these analyses are the following:

<u>Word Study Skills</u>. There were significant differences favoring girls at each grade level, with the mean differences ranging between 1.9 NCEs and 3.9 NCEs (Table 1).

<u>Reading Comprehension</u>. Girls scored significantly higher than boys at all grade levels. The mean differences decreased from an average of 4.3 NCEs for grades 2-4 to an average of 1.9 NCEs for grades 6-9

Table 1

SAT/7 Word Study Skills NCE Scores, by Sex: April, 1984

Grade	Boys Mean	Boys SD	Boys N	Girls Mean	Girls SD	Girls N	Difference (Boys-Girls)	F
2	44.72	16.15	2406	47.41	18.33	2368	-2.69	25.91**
3	44.39	16.82	2355	47.18	17.28	2391	-2.79	31.74**
4	44.64	22.32	2326	48.54	23.26	2297	-3.90	33.91**
5	46.61	19.07	2499	48.47	18.99	2449	-1.86	11.70**
6	45.27	17.93	2663	48.71	18.74	2625	-3.44	46.76**

**p < .01

Table 2

SAT/7 Reading Comprehension NCE Scores, by Sex: April, 1984

Grade	Boys Mean	Boys SD	Boys N	Girls Mean	Girls SD	Girls N	Difference (Boys-Girls)	F
2	48.18	20.75	2415	52.35	19.59	2367	-4.17	51.04**
3	48.84	18.85	2356	53.47	17.43	2388	-4.63	77.20**
4	48.45	21.26	2359	52.58	19.65	2316	-4.13	47.40**
5	49.92	22.39	2519	51.83	20.93	2465	-1.91	9.65*
6	48.29	20.24	2670	50.75	18.93	2636	-2.46	20.96**
7	48.55	19.88	3012	49.70	17.85	2876	-1.15	5.46*
8	51.84	20.64	2816	54.48	20.14	2859	-2.64	23.64**
9	52.41	21.89	2618	53.94	21.56	2703	-1.53	6.65*

*p < .05
**p < .01

(Table 2).

Total Reading. As expected, girls also scored significantly higher than boys at each grade level on Total Reading (Table 3), which is a composite of Word Study Skills and Reading Comprehension.

Concepts of Number. Boys scored significantly higher than girls at grades 3, 5, and 9, with grade 3 evidencing the largest mean difference (2.2 NCEs). There were no significant differences at grades 2, 4, 6, 7, and 8 (Table 4).

Mathematics Computation. Girls scored significantly higher than boys at all grade levels. The mean differences systematically increased across grades 2-6, peaking at 5.8 NCEs, then systematically decreased across grades 7-9 to a low of 1.8 NCEs (Table 5).

Mathematics Applications. No mean difference scores were significant at grades 2-7. Highly significant differences favoring boys, however, were observed at grades 8 and 9 (Table 6).

Total Mathematics. Non - significant difference scores favoring girls were observed at grades 2-5. Moreover, girls scored significantly higher than boys at grades 6 and 7. There was no mean difference at grade 8, and a non-significant difference favoring boys at grade 9 (Table 7).

These results, which were consonant with the general trends reported in research studies of differences in the reading and mathematics achievement of boys and girls, occasioned the following expanded study.

Expanded Study

The data based for this study was the third grade SAT/7 Reading Comprehension, Concepts of Number, Mathematics Computation, and Mathematics Applications subtest scores for 1983 and 1984. Grade three was chosen for analysis because the results of the preliminary study indicated it had the greatest number of statistically significant differences in mean NCE reading and mathematics scores between boys and girls. Two types of local third-grade norms were generated for each of the four SAT/7 subtests: total-group and sex-dependent norms. The norms were used to develop

Table 3

SAT/7 Total Reading NCE Scores, by Sex: April, 1984

Grade	Boys			Girls			Difference	F
	Mean	SD	N	Mean	SD	N	(Boys-Girls)	
2	44.92	19.00	2357	48.57	18.48	2336	-3.65	44.34**
3	46.05	16.83	2349	50.14	16.36	2385	-4.09	71.91**
4	46.67	21.25	2322	51.02	20.60	2294	-4.35	49.86**
5	46.65	20.69	2483	48.88	20.09	2435	-2.23	14.70**
6	47.32	19.73	2653	50.90	19.87	2619	-3.58	43.01**

**p < .01

Table 4

SAT/7 Concepts of Number NCE Scores, by Sex: April, 1984

Grade	Boys			Girls			Difference	F
	Mean	SD	N	Mean	SD	N	(Boys-Girls)	
2	54.30	20.31	2415	53.85	19.95	2372	0.45	0.60
3	58.02	19.52	2362	55.61	18.88	2396	2.21	15.84**
4	58.11	20.77	2372	57.05	19.72	2332	1.03	3.03
5	55.22	19.21	2531	53.30	18.64	2475	1.92	12.73**
6	54.91	21.32	2669	54.35	20.60	2632	0.56	0.93
7	53.95	18.45	3010	53.72	16.87	2883	0.23	0.26
8	55.79	21.29	2808	54.94	19.64	2861	0.85	2.42
9	55.52	23.21	2637	53.46	21.67	2778	2.06	11.37**

**p < .01

Table 5

SAT/7 Mathematics Computation NCE Scores, by Sex: April, 1984

Grade	Boys Mean	Boys SD	Boys N	Girls Mean	Girls SD	Girls N	Difference (Boys-Girls)	F
2	53.41	21.80	2409	56.18	21.30	2373	-2.77	19.78**
3	51.91	18.69	2361	54.49	17.64	2393	-2.58	24.03**
4	49.42	18.59	2368	52.97	17.17	2330	-3.55	46.17**
5	51.12	20.22	2528	55.44	19.17	2475	-4.32	59.97**
6	52.58	21.71	2658	58.40	19.94	2631	-5.82	103.32**
7	48.16	19.05	3008	51.74	17.28	2878	-3.58	56.93**
8	52.76	21.49	2816	55.76	19.30	2862	-3.00	30.76**
9	54.10	21.76	2647	55.90	20.32	2778	-1.80	9.86*

*p < .05
**p < .01

Table 6

SAT/7 Mathematics Applications NCE Scores, by Sex: April, 1984

Grade	Boys Mean	Boys SD	Boys N	Girls Mean	Girls SD	Girls N	Difference (Boys-Girls)	F
2	50.89	20.30	2414	50.70	19.74	2374	0.18	0.09
3	56.43	18.64	2355	56.00	17.66	2391	0.43	0.65
4	56.44	20.93	2375	56.05	19.24	2331	0.39	0.44
5	54.78	20.75	2526	54.52	19.50	2471	0.26	0.21
6	54.77	22.12	2666	54.38	20.40	2621	0.39	0.43
7	51.68	20.68	3018	51.41	16.60	2873	0.27	0.28
8	52.11	21.46	2804	49.88	18.77	2877	2.23	17.37**
9	53.32	22.96	2630	50.54	21.55	2756	2.78	21.06**

**p < .01

Table 7

SAT/7 Total Mathematics NCE Scores, by Sex: April, 1984

Grade	Boys Mean	Boys SD	Boys N	Girls Mean	Girls SD	Girls N	Difference (Boys-Girls)	F
2	53.82	20.23	2399	54.47	19.51	2360	-0.65	1.28
3	56.52	18.49	2339	56.86	17.65	2381	-0.34	0.40
4	54.93	20.19	2359	56.00	18.71	2316	-1.07	3.58
5	54.40	20.35	2509	55.48	19.44	2462	-1.05	3.67
6	54.35	21.74	2637	56.35	19.93	2606	-2.00	12.06**
7	52.14	19.43	2955	53.28	17.80	2837	-1.14	5.40*
8	53.65	20.28	2766	53.65	17.98	2827	0.00	0.00
9	54.57	21.34	2557	53.49	20.07	2697	1.08	3.58

*p < .05
**p < .01

Table 8

Number and Percent of Third Grade Boys and Girls: 1983 and 1984

Sex	1983 N	1983 %	1984 N	1984 %
Boys	2425	50.9	2411	49.5
Girls	2343	49.1	2468	50.5

Table 9

Number and Percent of Schools with Disproportionate Numbers of Third Grade Boys and Girls: 1983 and 1984

Percent Diff.	1983 N	1983 %	1984 N	1984 %
0-5	19	33.3	24	42.1
6-10	13	22.8	9	15.8
11-15	9	15.8	17	29.8
16-20	10	17.5	5	8.8
>20	6	10.5	2	3.5

total-group and sex-dependent district/school NCE scores.

Three general research questions were posed:

1. Are there differences between school NCE means obtained from total-group and sex-dependent norms?
2. Are there differences between the rank orderings of school NCE means obtained from total-group and sex-dependent norms?
3. Is there less change from 1983 to 1984 in school NCE scores obtained from sex-dependent norms than in those obtained from total-group norms?

The statistical techniques used to explore research questions one, two, and three were one-way analysis of variance, Spearman's rank-order correlation coefficient, and the Pearson product-moment correlation coefficient/t-test for correlated samples, respectively.

Results

Total District

The proportion of boys and girls at the district level of aggregation was virtually identical (Table 8); that at the school level, however, was not. Nearly 44 percent of the 57 schools containing grade three had more than a 10 percent difference in the number of third grade boys and girls (Table 9). Moreover, differences between the mean SAT/7 NCE subtest scores of the two sexes for 1983 and 1984 were congruent with the general trends reported in research studies and with the results of the preliminary study. Statistically significant differences in Reading Comprehension and Mathematics Computation favored girls, while those in Concepts of Number favored boys. The slight, non-significant differences in Mathematics Applications favored boys (Table 10).

Research Question 1. Are there differences between school NCE means obtained from total group and sex-dependent norms? There were a number of statistically significant differences between third grade SAT/7 NCE subtest means obtained from total-group and sex-

Table 10

Third Grade SAT/7 NCE Means, by Sex: 1983 and 1984

	1983							1984						
	Boys			Girls				Boys			Girls			
Subtest	Mean	SD	N	Mean	SD	N	t	Mean	SD	N	Mean	SD	N	t
Reading Comprehension	48.36	19.34	2022	52.44	17.53	2345	-7.63*	48.78	18.92	2411	53.42	17.55	2458	-8.87*
Concepts of Number	56.65	19.74	2419	54.65	19.13	2340	3.54*	57.94	19.60	2418	55.62	18.95	2467	4.22*
Mathematics Computation	50.75	18.14	2419	52.49	17.47	2343	-3.37*	51.08	18.75	2416	54.53	17.70	2464	-5.07*
Mathematics Applications	54.90	19.23	2417	54.83	17.65	2341	0.13	56.31	18.72	2410	55.84	17.84	2461	0.90

*$p < .001$

dependent norms. The proportion of schools evidencing such differences, however, fluctuated a great deal from 1983 to 1984 (Table 11). Over 15 percent of the schools had significant differences in Mathematics Computation for 1983, while only five percent reflected such differences in 1984. Conversely, the proportion of schools with significant differences in Concepts of Number increased from only 3.5 percent in 1983 to over 10 percent the following year. Decreases in the percent of schools evidencing such differences in Reading Comprehension and Mathematics Applications, although less dramatic, were also substantial.

All school difference scores fell within the range of ± 1 NCE, with the large majority of differences (84 percent both years) falling between ± 0.5 NCE (Table 12). Very few schools showed no differences in mean scores obtained from the two sets of norms.

Research Question 2. Are there differences between the rank orderings of school NCE means obtained from total-group and sex-dependent norms? To assess the practical impact of sex-dependent differences in student achievement on aggregated test scores, shifts in the rank orderings of schools were explored. In the large majority of instances where use of the different norm types caused changes in rank order, schools moved up or down only one position (Table 13). Additionally, all Spearman rhos between the mean SAT/7 NCE subtest scores obtained from the total-group and sex-dependent norms were .998 or greater (Table 14).

Research Question 3. Is there less change from 1983 to 1984 in school NCE scores obtained from sex-dependent norms than in those obtained from total-group norms? The analysis most crucial to the assumption underlying the use of sex-dependent norms concerned differences between the school NCE change scores obtained from the two norm types. All other things being equal, it was logical to assume that a substantial shift in the proportion of boys and girls would not affect NCE change scores obtained from sex-dependent norms. It should, however, affect those obtained from total-group norms. Similarly, schools with little or no shift in the proportion of the two sexes should reflect marginal differences between the

Table 11

Number and Percent of Schools with Statistically Significant Differences ($p < .05$) Between Third Grade SAT/7 NCE Means Obtained from Total-Group and Sex-Dependent Norms: 1983 and 1984

	1983		1984	
Subtest	N	%	N	%
Reading Comprehension	4	7.0	2	3.5
Concepts of Number	2	3.5	6	10.4
Mathematics Computation	9	15.8	3	5.2
Mathematics Applications	11	19.3	7	12.1

Table 12

Number of Third Grade SAT/7 NCE Mean School Difference Scores Obtained from Total-Group and Sex-Dependent Norms, by Range: 1983 and 1984 (N = 57)

	Number of Schools							
	1983				1984			
NCE Mean Diff. Range	RC	CN	MC	MA	RC	CN	MC	MA
-.99 to -.50	8	--	2	2	6	--	--	--
-.49 to -.01	23	27	42	49	20	41	26	40
0	3	4	--	1	--	--	3	3
.01 to .49	22	26	13	5	28	16	27	14
.50 to .99	1	--	--	--	3	--	1	--

Table 13

Shift in Rank Order of Third Grade SAT/7 School NCE Mean Scores Obtained from Total-Group and Sex-Dependent Norms, by Number of Ranks: 1983 and 1984

Number of Ranks	1983 RC	1983 CN	1983 MC	1983 MA	1984 RC	1984 CN	1984 MC	1984 MA
0	38	43	36	47	40	41	32	44
1	13	11	14	10	12	15	23	[illegible]
2	3	2	7	--	4	--	1	1
3	3	1	--	--	--	1	1	--
4	--	--	--	--	1	--	--	--

Table 14

Spearman Rank-Order Correlation Coefficients Between SAT/7 School NCE Means Obtained from Total-Group and Sex-Dependent Norms: 1983 and 1984 (N = 57)

Subtest	Spearman's Rho* 1983	Spearman's Rho* 1984
Reading Comprehension	.9983	.9985
Concepts of Number	.9991	.9992
Mathematics Computation	.9986	.9988
Mathematics Applications	.9987	.9985

*All values $p < .001$

respective change scores.

To test these assumptions, six extreme cases from the Reading Comprehension data were examined: three schools evidencing the largest changes from 1983 to 1984 in the proportion of boys (Group 1) and three schools evidencing the smallest of such changes (Group 2). The district performance of girls on this subtest in 1983 and 1984 exceeded that of boys by approximately 4.0 and 4.6 NCEs, respectively (Table 10). The results of this analysis indicated that, with one exception, the differences between the total-group and sex-dependent Reading Comprehension NCE change scores of the Group 2 schools were marginal, and that those for the Group 1 schools were approximately $\pm$ 1 NCE. The sex-dependent change scores of the two Group 1 schools with an approximate 20 percent increase in boys, however, were larger than the corresponding total-group scores. Only for that school with a 26 percent decrease in the proportion of boys was the sex-dependent change score smaller than the total-group change score (Table 15).

As expected, there were non-significant differences between all four pairwise comparisons of mean NCE change scores at the district level of aggregation (Table 16). Moreover, because these differences were marginal, the use of sex-dependent norms had virtually no practical effect on the changes in school rankings from one year to the next. In fact, for each norm type, the Pearson product-moment correlations between the respective subtest means for 1983 and 1984 were either identical or within .01 point of each other (Table 17).

Summary and Conclusions

The results of the preceding analyses indicated that there were statistically significant differences between the reading and mathematics performance of third grade boys and girls at the district level of aggregation which were consonant with those identified in previous research studies: girls scored higher than boys on Reading Comprehension and Mathematics Computation, while boys outperformed girls on Concepts of Number. The use of total-group and sex-dependent

Table 15

Differences Between Reading Comprehension Mean NCE Change Scores for Selected Schools: 1983 and 1984

Group/ School	Change in Pct. Boys ('84-'83)	RC Change Score ('84-'83) Total-Group	Sex-Dependent	Diff. (TG-SD)
Group 1				
1	-26	5.82	4.77	1.05
2	21	5.58	6.66	-1.08
3	19	8.77	9.70	-0.93
Group 2				
4	1	5.61	5.51	0.10
5	0	5.01	5.17	-0.16
6	-1	1.77	1.12	0.65

Table 16

Differences Between Third Grade SAT/7 School Mean NCE Score Changes Obtained from Total-Group and Sex-Dependent Norms (N = 56)

	Type of Norms					
	Total-Group		Sex-Dependent		Difference	
Subtest	Change	SD	Change	SD	(TG-SD)	t*
Reading Comprehension	3.51	2.65	3.58	2.71	-.07	-.85
Concepts of Number	5.09	4.04	5.02	4.00	.07	1.80
Mathematics Computation	5.16	4.18	5.20	4.24	-.04	[illegible]
Mathematics Applications	3.69	2.84	3.70	2.80	-.01	[illegible]

*None significant p < .05

Table 17

Pearson Product-Moment Correlation Coefficients Between 1983 and 1984 Third Grade SAT/7 School NCE Means Obtained from Total-Group and Sex-Dependent Norms (N = 56)

	Type of Norms	
Subtest	Total-Group	Sex-Dependent
Reading Comprehension	.83	.82
Concepts of Number	.65	.66
Mathematics Computation	.58	.58
Mathematics Applications	.81	.81

norms produced statistically significant mean NCE differences at the school level of aggregation in approximately 10 percent of the cases. These differences, however, were quite small, all within ± 1 NCE, and most no greater than ± 0.5 NCE. Moreover, changes in the rank orderings of schools occasioned by the use of the two norm types were neither widespread nor large--typically an upward or downward shift of only one position--which accounted for the extremely high Spearman rho correlations. Finally, the sex-dependent NCE change scores for schools evidencing the greatest shifts in the percent of boys were not consistently smaller than the corresponding total-group NCE change scores, nor were any of the differences between the two NCE change scores statistically significant at the district level of aggregation. Hence, it may be concluded that the differences in third grade school NCE reading and mathematic means, rank orderings, and change scores were not sufficient to justify the use of sex-dependent norms for such purposes as program evaluations, merit school award programs, district rankings, and longitudinal comparisons of schools.

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