DOCUMENT RESUME

ED 454 246 TM 032 849

AUTHOR	Lubienski, Sarah Theule
TITLE	A Second Look at Mathematics Achievement Gaps: Intersections of Race, Class, and Gender in NAEP Data.
PUB DATE	2001-04-13
NOTE	20p.; Paper presented at the Annual Meeting of the American Educational Research Association (Seattle, WA, April 10-14, 2001).
PUB TYPE	Reports - Evaluative (142) -- Speeches/Meeting Papers (150)
EDRS PRICE	MF01/PC01 Plus Postage.
DESCRIPTORS	*Black Students; Elementary Secondary Education; *Equal Education; Interaction; Low Achievement; *Mathematics Achievement; *Racial Differences; *Sex Differences; *Socioeconomic Status; White Students
IDENTIFIERS	*National Assessment of Educational Progress

ABSTRACT

Drawing from 1990 and 1996 data from the National Assessment of Educational Progress (NAEP), this study examined disparities between White and African American students' mathematics performances and classroom experiences, with attention to interactions among race, socioeconomic status (SES), and gender. Overall, NAEP scores increased for both White and African American students, but substantial race- and SES-related differences remained. SES differences appeared to account for some, but not all race-related differences. Additionally, some potential underlying factors were found to correlate with race even after controlling for students' SES, including limited calculator use, multiple choice assessment use, lack of teacher emphasis on reasoning, and students' views of mathematics as memorization. By going beyond the traditional, discrete examination of race, class, or gender in isolation, this study helps clarify the gaps in mathematics achievement and sheds light on potential factors underlying these gaps. (Contains 5 tables and 28 references.) (Author/SLD)

Reproductions supplied by EDRS are the best that can be made
from the original document.

TM

ED 454 246

U.S. DEPARTMENT OF EDUCATION
Office of Educational Research and Improvement
EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)
☑ This document has been reproduced as received from the person or organization originating it.
☐ Minor changes have been made to improve reproduction quality.
• Points of view or opinions stated in this document do not necessarily represent official OERI position or policy.

PERMISSION TO REPRODUCE AND DISSEMINATE THIS MATERIAL HAS BEEN GRANTED BY
S. T. Lubienski
TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)
1

A Second Look at Mathematics Achievement Gaps: Intersections of Race, Class, And Gender In NAEP Data

Paper presented at the annual meeting of the
American Educational Research Association, Seattle, 2001

Sarah Theule Lubienski
Iowa State University

Abstract

Drawing from 1990 and 1996 data from the National Assessment of Educational Progress, this study examines disparities between White and African American students' mathematics performance and classroom experiences, with attention to interactions among race, socioeconomic status and gender. Overall, NAEP scores increased for both White and African American students, but substantial race- and SES-related differences remain. SES differences appeared to account for some, but not all race-related differences. Additionally, some potential underlying factors were found to correlate with race even after controlling for students' SES, including limited calculator use, multiple choice assessment use, lack of teacher emphasis on reasoning, and students' views of mathematics as memorization. By going beyond the traditional, discrete examination of race, class or gender in isolation, this study helps clarify the gaps in mathematics achievement and sheds light on potential factors underlying these gaps.

TM032849

Introduction

Although achievement gaps between White and minority students narrowed in the 1970s and 80s (Tate, 1997), scholars are now concerned about the widening gaps between African American and White children's achievement (e.g., Jencks & Phillips, 1998). These concerns relate to a number of subject areas. However this article focuses on one particular subject: mathematics.

Mathematics serves as a "critical filter" in our society, with the potential to reward successful students with high occupational status and pay (Campbell, 1991). Not only can mathematics achievement serve as a ladder of economic mobility, it is also essential for making informed consumer and voter choices. Moreover, Moses (1994) argues that mathematical literacy is key in the fight for racial equality.

The National Council of Teachers of Mathematics (NCTM, 1989; 1991; 2000) has called for "mathematical power for *all*" including for African Americans and other students who have traditionally been under-represented in mathematics-related careers. NCTM's vision of mathematics classrooms centered around problem solving, collaboration, and discussion sounds promising in many ways for promoting equity. For example, several researchers have noted that students of lower socioeconomic status (SES)[1] and minority groups have received more than their share of rote learning and low-level exercises from teachers who expect little of them (e.g., Anyon, 1981; Knapp, Shields, & Turnbull, 1995; Means & Knapp, 1991). Moreover, some scholars argue that African-American students tend to prefer working in more relational, holistic ways, as opposed to memorizing and following rigid rules in isolation (Stiff, 1990). Hence, the current reforms would seem to hold promise, not simply for "all students," but particularly for African American students.

One way to investigate possible effects of these reforms is to examine data from the National Assessment of Educational Progress (NAEP). The NAEP is the only nationally representative, ongoing assessment of academic achievement in the United States. The NAEP measures student performance at 4th, 8th, and 12th grades in mathematics and other subject areas. The NAEP also provides information from student and teacher questionnaires regarding classroom practices. Since 1990, the main[2] NAEP mathematics assessment has been shaped by a framework based on the NCTM Curriculum and Evaluation Standards for School Mathematics (1989). As early as 1992, changes in the NAEP mathematics scores were attributed by some to the NCTM Standards. For

[1] Socioeconomic status can be thought of as an approximation for social class, which connotes more permanence, shared group values, and beliefs about roles in society and relationship to power (Secada, 1992).

[2] There are two different NAEP mathematics assessments: the main assessment and the long-term trend assessment. The framework that determines the content of the main assessment is responsive to national trends, such as the recent emphasis on the NCTM *Standards*. The long-term trend assessment was created in 1973 and has remained constant over time. The long-term trend assessment was most recently administered in 1999, whereas the main assessment was administered in 1996 and again in 2000 (the raw data from the 2000 assessment will not be available to researchers until late 2001.)

example, in an NCTM Bulletin article entitled, "NAEP Results Show Improvement," then Secretary of State, Lamar Alexander, credited the NCTM reforms for the "improved" scores (NCTM, 1993). But a closer look at the fine print in the article reveals that, although White students' scores increased at all three grade levels tested, Black[3] and Hispanic students' scores were up only at the 12th grade level. Moreover, there was a significant decline in the average proficiency of eighth graders from "disadvantaged, urban areas."

In addition to reporting student scores, NAEP uses those scores to classify students' performance as "below basic," "basic," "proficient" or "advanced." Reese, Miller, Mazzeo & Dossey (1997, p. 55) report that in 1996, the percentage of Black students whose performance was "below basic" was an alarming: 68, 72, and 62 for 4th, 8th, and 12th graders respectively. In comparison, the percentages for White 4th, 8th and 12th graders were 24, 26, and 21. Given that the definition for the "basic" level of achievement is "partial mastery of prerequisite knowledge and skills that are fundamental for proficient work at each grade," it is alarming that about two-thirds of African American students are not meeting this level of achievement.

Several other reports have also been published that summarize various facets of the 1996 NAEP mathematics results (e.g., Kenney & Silver, 2000; Mitchell, Hawkins, Jakwerth, Stancavage, & Dossey, 1999). These documents give attention to equity by reporting achievement results in four isolated categories: race, gender, parent education level and home literacy resources. These NAEP reports tend to acknowledge the conflation of race and class in the results, but do not attempt to disentangle these factors. For example, Strutchens and Silver (2000) write, "Because Black and Hispanic students are over-represented in low-income categories. . .[it is] difficult to untangle matters of race/ethnicity and economic conditions in these NAEP findings." (p. 51) They caution that the race-related differences in NAEP results they report might be due to SES more than race. Hence, the reports tell us little about whether "Black-White" achievement gaps are larger for lower- or higher-SES students, or for males or females.

The mainstream mathematics education research community has given relatively little attention to equity issues relating to ethnicity, and almost no attention to interactions among ethnicity, social class and gender. In a survey of 3,011 mathematics education research articles published between 1982 and 1998, Lubienski and Bowen (2000) found 323 articles pertaining to gender, 52 pertaining to social class, and 112 pertaining to ethnicity. Of the 112 articles on ethnicity, 47 pertained specifically to African American students. Only 3 of the 3,011 articles considered ethnicity, class and gender together.

[3] NAEP uses the term "Black" as opposed to "African American." Also, the term "race" is used, as opposed to "ethnicity". Although I acknowledge the differences of opinion that exist about such terms, I will be using the terms NAEP uses as I report the data in order to be consistent with the original reporting.

It is difficult to look at equity-related variables in conjunction with one another and to separate the various effects of each variable. Sample sizes, sample demographics, and limited researcher time and expertise can be barriers to conducting such detailed analyses. Still, it is important to consider possible interactions among ethnicity, class and gender in order to deepen our understanding of mathematics achievement differences (Reyes and Stanic, 1988). This study goes beyond previously published NAEP reports by examining interactions among ethnicity, SES and gender in NAEP mathematics achievement and classroom practices.

Statement of Purpose

This study investigated 1990 and 1996 NAEP scores to examine disparities between White and African American students' mathematics performance, with attention to interactions with SES and gender. These two assessments were chosen because 1990 was the first assessment aligned with the NCTM Standards, and 1996 is the most recent (for which data is available). The study considers both achievement data, as well as potential factors contributing to achievement differences, including disparities in access to instruction aligned with the NCTM *Standards*. (These instructional disparities are discussed in more detail in Lubienski, 2001.) This study deepens our understanding of achievement disparities and can inform efforts to promote equity in mathematics education.

Method

NAEP samples consist of several thousand 4th, 8th and 12th graders from both public and private schools. Although the NAEP's main focus is academic achievement, the students, their teachers and administrators complete detailed questionnaires pertaining to a variety of background variables, including students' attitudes and study habits, teachers' instructional emphases, and school policies.

There are several features that make NAEP data particularly difficult to analyze. These features include the use of multi-staged, stratified random sampling (in which geographic areas, then schools and then students are selected), the oversampling of private school and minority students, and the use of plausible values to estimate scores for each student based on his/her background and performance on a subset of items. (For more information about these statistical issues, see Johnson (1992) or Johnson and Rust (1992).) The special weighting and jackknifing needs of NAEP analyses are addressed by a special software program called NAEPEX (that works in conjunction with SPSS), designed by the Educational Testing Service.

In this study, NAEPEX software was used to extract and create SPSS code for relevant variables from the 1990 and 1996 main mathematics NAEP data sets. Variables included were

those that pertained to students' mathematics achievement, demographics, attitudes, behaviors, and teachers' backgrounds and instructional philosophies.

From students' self-reports (or when this information is missing, school records), NAEP categorizes students' race as one of the following: White, Black, Hispanic, Asian/Pacific Islander, and American Indian (including Alaskan Native). Analyses of race reported here involve comparisons between White and African American students only. This relatively narrow focus is due to both recent concerns about the growth in the gap between Black and White students' achievement (e.g., Jencks & Phillips, 1998), as well as a concern about NAEP sample sizes for other minority groups becoming too small when examined in conjunction with SES.

In order to examine trends relating to SES across the 1990 and 1996 data, I constructed an SES variable using the two most relevant variables present in both data sets: resources in the home (books, encyclopedia, magazines, newspapers) and parental education. The ideal would have been to create a continuous SES variable, but both variables were discrete and contained only 3-4 values. Parental education information is not reported for about one third of 4th graders, posing yet another difficulty. After considering both the much-debated meaning of "socioeconomic status" and the percentages of students in each cell of Table 1 across 4th, 8th and 12th grades for both 1990 and 1996, I assigned students to an "SES quartile" as follows:

Table 1: SES Quartile[1] Assignments

Resources in the Home	Did not finish high school	Finished high school	Some post-high school education	College degree	Parent education missing
0-2 Resources[2]	1st quartile	1st quartile	2nd quartile	2nd quartile	1st quartile
3 Resources	1st quartile	1st quartile	2nd quartile	3rd quartile	2nd quartile
4 Resources	1st quartile	2nd quartile	3rd quartile	4th quartile	3rd quartile
Home Resources missing[3]	1st quartile	1st quartile	2nd quartile	3rd quartile	missing SES

Table Notes:

1) I refer to the four categories as "quartiles," although the actual percentage of students in each group varied, depending on the sample.
2) So few students report having less than 2 of the 4 resources in the home, that NAEP collapses the categories to be 0-2 items, 3 items or 4 items. "Parent Education" refers to the higher of either the mother or father when they differ.
3) When either parent education or home environment information was missing, I assigned the student to the SES quartile that he/she was most likely to be in, given the value of the other variable. If a student's parent education and home environment information was missing, the student was excluded from SES-based analyses.

The crosstabs feature of the NAEPEX module was used to calculate means and standard errors for student achievement data, as well as student and teacher questionnaire data. Fourth, eighth, and twelfth grade achievement data for each mathematical strand — number, geometry, measurement, data, and algebra — were compared across intersections of SES, race, and gender groups, with an eye toward changes in gaps between 1990 and 1996. Additionally, teacher-related data were compared to investigate potential correlations between achievement gaps and teachers' instructional emphases.

Results

In order to help the reader interpret the results, some information about the NAEP achievement scale is necessary. NAEP uses a consistent 500 point scale on which 1996 4th graders scored an average of 224 and 12th graders scored an average of 304. Hence, a 10-point achievement gap can be thought of roughly as a one-year difference.

The findings reported below tend to point toward areas of concern, but there are important positive findings to be noted. First, overall scores have increased for every mathematical strand in every grade. When disparities between African American and White students have worsened, this is generally because the gains of White students were larger than the gains of African American students. Additionally, there are ways in which the achievement and teacher emphases for some strands — especially algebra and geometry — have become more uniform across groups. For example, in 1990 White fourth graders were more likely than Black fourth graders to have a teacher who reported giving significant emphases to algebra, but that gap had closed by 1996.[4]

Figure 1 reports the NAEP sample sizes, as well as the percentage of Black and White students in each SES quartile. As Figure 1 reveals, higher proportions of White students were in the higher SES quartiles, whereas higher proportions of Black students were in the lower quartiles. However, the figure also reports a positive trend of slightly more White and Black students in the higher quartiles in 1996 than in 1990. Still, the substantial SES disparities between White and Black students do not appear to be significantly changed.

[4] Small but significant race- and SES-related gaps remained in terms of algebra emphasis in 8th grade.

Figure 1: 1990 and 1996 Percentages of White and Black Students In Each SES Quartile

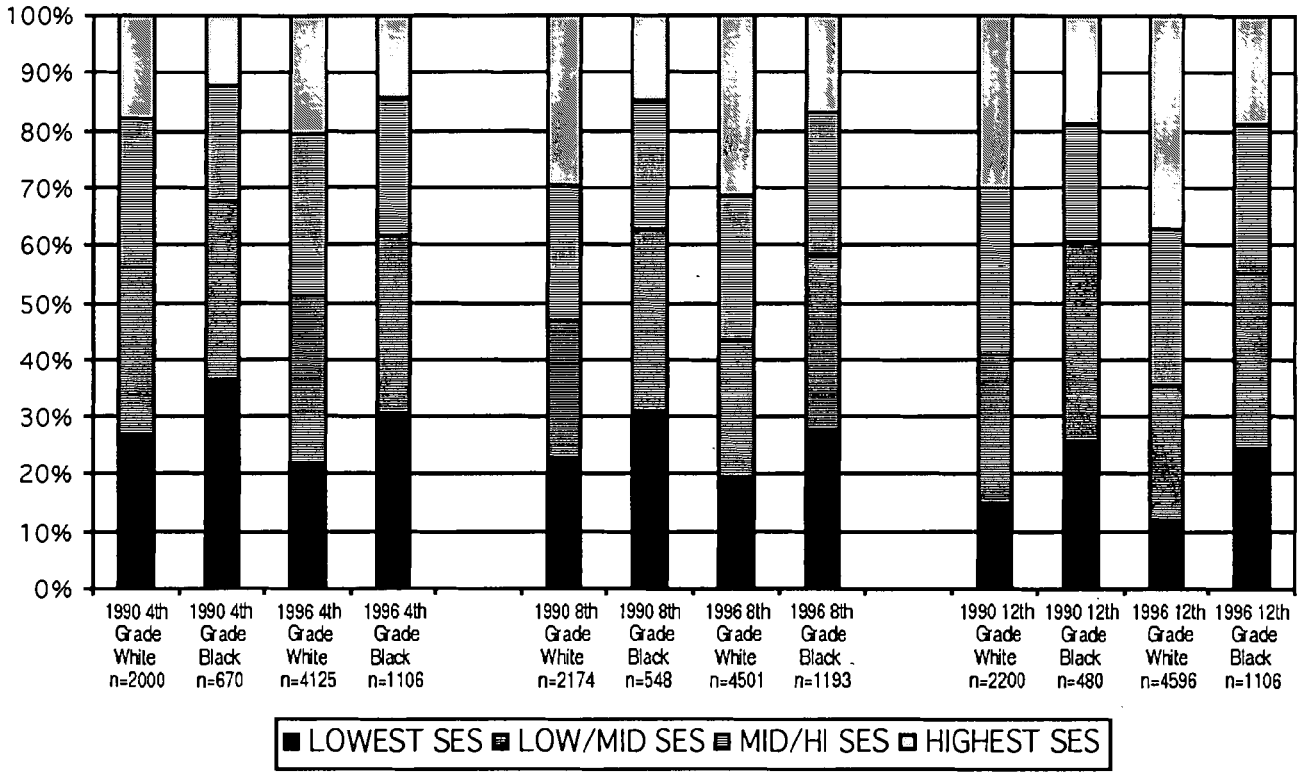


Figure Note: These numbers are the unweighted sample sizes. In 1990, Black students were weighted as roughly 15% of the population (the percentage varies slightly depending on the grade level), and in 1996 were weighted as roughly 14%. White students were weighted as roughly 71% of the population in 1990 and 69% in 1996. (Hispanic student weight increased from about 9% in 1990 to 12% in 1996.)

General Mathematics Achievement: 1990 To 1996

In contrast with race and SES, educators have given significant attention to the gender gap in mathematics education over the past three decades (Lubienski & Bowen, 2000). In 1996, there were no longer significant gender differences in 8th and 12th grades, and there was an increased (up from 1 point in 1990) but still small 3.4 point gap favoring males at the 4th grade level.[5] An exploration of SES, and gender together revealed that this 1996 4th grade gap is concentrated at the highest SES group, where the gap is 6.7 points (see Table 2). However, this trend was stronger for high-SES White students (7 point gap) than high-SES Black students (2.2 point gap). In fact, overall there is no gender gap for African American students at 4th or any other grade.

[5] This is significant at the $p<.05$ level using a two-tailed test. Significance tests reported in this article are two-tailed tests, using .05 as the critical p value.

Table 2: Mean Mathematics Achievement by Gender and SES

1996 4th Grade	1st SES quartile	2nd SES quartile	3rd SES quartile	4th SES quartile	TOTAL
Male	211.8(1.9)	221.3(1.5)	231.8(1.5)	**241.5(2.0)**	225.6(1.1)
Female	209.7(1.8)	221.1(1.3)	228.3(1.3)	**234.8(1.4)**	222.2(1.0)
Gender Gap	2.1	.2	3.5	**6.7***	3.4*
Total	210.7(1.7)	221.2(1.1)	230.1(1.1)	238.3(1.5)	223.9(0.9)

Any existing gender gaps pale in comparison to the highly significant gaps between Black and White students, as well as the gaps between the lowest- and highest-SES students (See Table 3). In 1996, the Black-White gap was 32 points at fourth grade (up from 31 points in 1990), 39 points at 8th grade (up from 32 points in 1990), and 31 points at 12th grade (down 1 point since 1990). To put some perspective on the severity of these differences, note that the average score of African American 12th graders was lower than that of White 8th graders. Gaps between the lowest and highest SES quartiles were slightly smaller than the Black-White gaps: an average of 25 points (down from 30 in 1990) for White students, and only 18 points for Black students (unchanged since 1990).

Table 3: Mean Achievement by Race and SES

	Fourth Grade			Eighth Grade			Twelfth Grade		
	All Quartiles	Lowest SES Quartile	Highest SES Quartile	All Quartiles	Lowest SES Quartile	Highest SES Quartile	All Quartiles	Lowest SES Quartile	Highest SES Quartile
1990									
White	220 (1.1)	211 (1.2)	234 (2.0)	270 (1.4)	251 (1.9)	284 (1.5)	301 (1.2)	280 (2.4)	313 (1.7)
Black	189 (1.8)	184 (2.6)	197 (3.5)	238 (2.7)	228 (3.2)	251 (4.3)	268 (1.9)	260 (3.1)	277 (3.8)
1996									
White	232 (.9) *+ 12*	222 (1.7) *+11*	245 (1.3) *+11*	282 (1.2) +12	265 (1.7) *+14*	293 (1.5) *+9*	311 (1.0) +11	295 (1.4) *+15*	319 (1.1) *+6*
Black	200 (2.3) *+ 11*	192 (2.2) *+ 8*	206 (4.5) *+9*	243 (2.0) +5	233 (2.0) *+5*	252 (2.3) *+1*	280 (2.2) +12	269 (2.1) *+9*	290 (4.3) *+13*
Current Black/ White Gap	32	30	39	39	32	41	31	26	29
Change in Black/ White Gap since 90	*+ 1*	*+ 3*	*+ 2*	*+ 7*	*+ 9*	*+ 8*	*-1*	*+ 6*	*-7*

Table Notes: Standard errors are in parentheses. To simplify the detailed nature of this information, all achievement scores have been rounded to the nearest integer. Changes from 1990 to 1996 are noted in italics. The 1990 and 1996 Black/White gaps for each grade level are significant, but the changes in the gaps are not.

One might wonder if the Black-White gap is primarily about class differences rather than race. Although class is certainly a factor, the short answer appears to be "no." Consistently across the

three grades in both 1990 and 1996, the *lowest*-SES White students scored equal to or higher (often significantly so) than the *highest*-SES Black students.[6]

An analysis of these achievement trends in conjunction with gender (using SES halves instead of quartile extremes in order to preserve sample size) revealed a disturbing pattern at the 12th grade. Although the Black/White 12th grade gap did not change significantly between 1990 and 1996, the gap between lower-SES Black males and other groups significantly increased. In particular, the average Black male score in the lower SES half increased by only 1 point, but both lower- and higher SES Black females' scores increased by about 14 points, and upper-SES Black males increased by over 17 points. Hence, although 12th grade Black students gained an average of 12 points (and narrowed the gap between themselves and White students by 1 point), lower-SES Black males appeared to be left behind. Still, the lower-SES Black females' 1996 scores were not significantly higher than those of the lower-SES males, since they were over 10 points behind the males in 1990.

A Closer Look at 1996 Performance: Mathematical Strands

The NAEP mathematics assessment is divided into five mathematical strands: number and operations, geometry, measurement, data analysis and statistics, and algebra and functions. Overall student performance varied only slightly by strand, however an exploration of the race, class and gender gaps on each mathematical strand revealed several patterns.

The Black/White gap was largest in measurement for all three grade levels in both 1990 and 1996, with data analysis/statistics taking second place (see Table 4). The pattern was most striking in 8th grade, where the 1996 gap for measurement was 54 points, up 15 points from 1990. The increase in the gap was due to the performance of White students increasing 15 points while that of Black students remained unchanged.

The SES gaps were significant and fairly similar across the five strands in 4th and 12th grades. In 8th grade (1996), the SES gaps for measurement (28 points) and data (27 points) stand out as the largest among the strands. However, SES does not seem to explain the Black-White gap in 8th grade measurement scores. The highest SES quartile of Black 8th graders scored a significant 22 points lower than the lowest-SES White 8th graders (239 versus 261).

[6] Recall that I did not include school lunch eligibility as a factor in determining SES because this variable was not available in the 1990 data set. Using the 1996 data only, I reanalyzed this particular pattern (low-SES White students versus high-SES Black students) using a "stronger" SES variable based on the SES quartiles as defined previously, combined with school lunch eligibility. In doing so, the pattern weakened somewhat, so that the highest-SES Black students scored slightly (not significantly) higher than the lowest-SES White students at each grade level. However, it is important to note that the SES groups under consideration were much smaller in size than in the original analysis using "quartiles", with each group now representing only about 7% of each ethnic group.

Table 4: 1990 and 1996 Black-White Gaps by Mathematical Strand

Black-White Gap	Number	Msmnt	Geo	Data	Algebra	Overall Achvmnt.
4th 90 Gap	30	36	29	-	30	31
4th 96 Gap	31	35	32	34	28	32
Change	**+1**	**-1**	**+3**	**-**	**-2**	**+1**
8th 90 Gap	28	39	32	39	29	32
8th 96 Gap	34	54	35	46	33	39
Change	**+6**	**+15**	**+3**	**+7**	**+4**	**+6**
12th 90 Gap	27	37	36	35	30	33
12th 96 Gap	29	39	30	34	26	31
Change	**+2**	**+2**	**-6**	**-1**	**-4**	**-2**

Table Notes: In 1990, there was no "data analysis and statistics" portion of the 4th grade assessment. NAEP overall achievement scores are a weighted average of the five strands, with each strand's weight varying by grade level. All gaps are statistically significant. Only the change in the measurement gap at 8th grade is a statistically significant change.

Some Specific Examples From the NAEP Special Theme Assessment

In addition to the regular NAEP assessment, there was a special theme assessment in 1996 that involved having students solve multi-step, mathematics problems set in real-world contexts. At each grade level, two problems were given, each with several sub-questions. The achievement disparities on these contextualized problems were more marked than those on the regular assessment. Some of the problems with the largest disparities, again, involved measurement. Although I did not perform analyses of race, class and gender interactions on this special assessment, I draw from the detailed examples of problems and student responses that Mitchell, Hawkins, Stancavage, and Dossey (1999) report in order to delve more deeply into some of the issues raised in the above data. The Black-White disparities revealed here point toward differences in students' opportunity to learn fundamental mathematical concepts relating to measurement and other key areas.

One question asked fourth graders to measure the wingspan of a given butterfly using a centimeter ruler. As Mitchell et al. Report, 47% of White students and only 20% of Black students did this correctly. 2% of White students and 8% of Black students omitted the question. One possibility is that more White students than Black students were familiar with the term "wingspan." However, another problem in 8th grade also showed a disparity in knowledge about using a ruler to measure. This problem asked students to measure, in inches, three aspects of a model doghouse (to be assembled out of pieces provided). 54% of White students made the three

measurements correctly, compared with only 17% of Black students. Also, 17% of Black students omitted the question, compared with 6% of White students.

One key aspect of mathematics linked with both measurement and algebraic understanding is ratio. The disparities in 8th graders' responses to a question asking how to use a scale of 1 inch = 1.5 feet to convert measurements of the model dog house to real measurements again suggest disparities in students' opportunities to learn these ideas. Only 9% of Black students, compared with 38% of White students answered the question at least partially correctly. Of perhaps even greater concern is that 36% of Black students omitted the question (compared with 16% of White students). Another measurement-related problem involved fencing a dog pen with 36 feet of fence. Students were asked to find the dimensions of the rectangular yard that would give the maximum area. 34% of White students compared with 10% of Black students got the problem at least partially correct. 21% of White students compared with 45% of Black students omitted it.

One of the problems on the 12th grade theme assessment differed from the 4th and 8th grade problems in that it contained sub-questions strictly involving computation with numbers in a money situation. On one such multiple-choice question that involved calculating a 20% downpayment for a car, overall performance was higher and disparities smaller than in other problems: 86% of White students and 73% of Black students answered correctly. As the computation-based problems became more open-ended and more complicated, all students did worse, and more students omitted the problems. Still, the Black-White disparities on most number-related problems appeared smaller than the disparities on the 4th and 8th grade problems involving measurement and geometry.

Searching for Explanations

The NAEP is not longitudinal nor designed for making cause-and-effect inferences regarding instructional methods and student outcomes. However, analyses of NAEP student and teacher questionnaires can reveal similarities and differences in students' classroom experiences and attitudes, thereby shedding light on factors that could shape the achievement differences noted above. Strutchens and Silver (2000) recently summarized the 1996 NAEP data pertaining to race-related patterns in students' school experiences, attitudes and beliefs. In this section, I draw from their analyses as I explore factors that do or do not correlate with the achievement disparities noted above. For those factors that appear to correlate with Black-White achievement differences, I go beyond Strutchens and Silver's race-focused analyses to explore interactions between race and SES, as well as gender, where appropriate.

Student Course Taking

According to Strutchens and Silver (2000), both Black and White seniors reported taking more mathematics in 1996 than in 1990 or 1992. Additionally, the Black-White gaps in algebra and

geometry course-taking narrowed. However, there continue to be differences in pre-calculus and calculus enrollmcnt. In 1996, 7% of Black students, compared with 13% of White students reported taking calculus, and 25% of White seniors, compared with 17% of Black seniors took pre-calculus. The Black-White gaps for these courses have not improved since 1992.

My closer analysis of the course-taking data revealed a newly closed gender gap that could relate to the increase of lower-SES Black females' math scores (while the scores of lower-SES Black males did not increase). In 1990, only 47% of lower-SES Black females reported taking a mathematics course their senior year, compared with 72% of lower-SES males. In 1996, the percentage for these females increased to 62%, while there was no change for the males. (A similar pattern existed for the achievement and course taking patterns for 12th grade lower-SES Hispanic males and females.)

Yet overall, course taking gaps appear to be more related to SES than race. For example, although there are significant gaps between the percentage of lower- and higher-SES 12th graders who reported taking algebra before 9th grade, there are slight but insignificant gaps between Black and White students within each SES category. This fact, in addition to the fact that course-taking differences are more present in high school than 4th and 8th grades, leads one to conclude that course-taking differences exist, but leave much of the Black-White achievement gap unexplained.

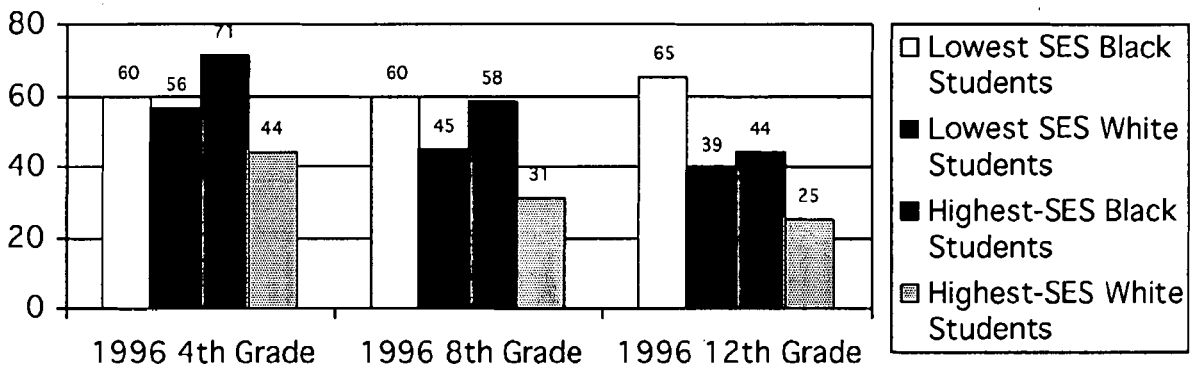
Student Behaviors, & Beliefs

On the 1996 NAEP survey, students were asked how much time they spend on homework, as well as about their attitudes toward mathematics, including whether they like the subject and believe it is useful. These factors do not correlate with the Black/White achievement gaps in mathematics. Black students report spending more time than White students on mathematics homework. Students' liking of mathematics, as well as beliefs about its usefulness also do not appear to explain the Black/White achievement gaps, since Black students report liking mathematics and believing it is useful at least as much as White students. Furthermore, students' beliefs about the correlation between effort and achievement do not explain the gap. In 1996, 31% of White 8th graders versus 59% of Black 8th graders "strongly agreed" with the statement, "All can do well in math if they try."

Still, there are some differences in students' beliefs that could be related to the mathematics achievement differences. Black students were more likely than White students to agree that there is only one way to solve a math problem. This pattern was stronger for race than for SES, and was also stronger at the 4th grade level than in later years. Additionally, lower-SES and Black students were more likely than White and upper-SES students to agree with the statement, "Learning mathematics is mostly memorizing facts" (see Figure 2). Although students generally appear to move away from this belief as they move through school, the Black-White and SES gaps grow as

students are in school, and the gaps are larger between Black and White students than between the lowest and highest SES students. Additionally, although this view was strongly tied to SES for White students (with higher-SES students less likely to view math as memorization), the belief persisted across all SES levels for Black 4th and 8th graders. At each grade level, a larger percentage of high-SES Black students than low-SES White students agreed that mathematics learning is primarily fact memorization. Overall, by 12th grade, only 29% of White students agreed, but 55% of African American students agreed.

Figure 2: Percentage of students agreeing with the statement, "Learning mathematics is mostly memorizing facts."[7]



One possible explanation for these differences in student beliefs is that Black and White students could be receiving different forms of mathematics instruction. The following section explores this hypothesis further.

Instructional Practices

The National Council of Teachers of Mathematics is promoting new instructional methods to be used with *all* students. A major thrust of NCTM's initiative is to help students view mathematics in terms of problem solving and sense making. The fact that almost two thirds of African American 4th graders and over half of African American 12th graders viewed mathematics learning as memorization suggests that perhaps the NCTM reforms are being implemented more for White students than for African American students.

[7] At the 4th and 8th grade levels, the overall SES and race-related differences are significant. The SES differences are significant for White students but not Black students. At the 12th grade level, the overall SES- and race-related differences are significant, as are the SES differences for both White and Black students.

NAEP data on 4th and 8th grade teachers' instructional practices shed some light on this subject. (12th grade teachers were not surveyed about their instructional practices.) First, there are a number of areas in which White students do not appear to be experiencing Standards-based instruction any more than Black students. Briefly, these areas include the use of manipulatives, the use of "real-life" mathematics problems, and student collaboration. Also, there were no differences in teachers' reported knowledge about, and professional development in the NCTM *Standards* that related to the race of their students. Additionally, the teachers of Black students reported spending more time per week on mathematics instruction than teachers of White students.[8]

Hence, there are ways in which NCTM-based instructional practices seem to be reaching Black students, at least on the surface. However, other NAEP evidence suggests that White students are experiencing more of the fundamental shifts called for by NCTM.

One area in which differences appear is technology use. Although teachers of Black students report having as much access to technology as those of White students, there are differences in the ways in which this technology is used. For example, although Black 8th graders appear more likely than White 8th graders to use computers in math class, this usage is most often for drill and practice or games, whereas White students are more likely to have computers used for simulations, demonstrations or applications of concepts. This pattern was not significantly related to SES. Additionally, although calculator use has dramatically increased since 1990, African-American 8th graders are still less likely to use them as a regular part of mathematics instruction or assessment (see Table 5). For example, in 1996, 61% of White students, compared with 32% of Black students had a teacher who reported allowing students to use calculators "almost every day." Similarly, 72% of White students, compared with 51% of African American students had teachers who reported allowing the use of calculators on tests. These gaps between White and Black students increased between 1990 and 1996, and are slightly larger than the gaps between the lowest and highest SES quartiles. In both cases, the 1996 Black-White differences are not simply attributable to student SES differences, as the highest SES quartile of Black students had teachers who allowed less calculator access than teachers of the lowest-SES quartile of White students.

[8] The NAEP sample involves a random sample of students, and not teachers. Therefore, claims must be made at the student, not teacher, level.

Table 5: Calculator Use

	Percentage of 8th graders whose teachers responded "almost every day" to "How often do students use a calculator?"		Percentage of 8th graders whose teachers responded "yes" to "Do you permit the use of calculators on tests?"	
	1990 8th Grade	1996 8th Grade	1990 8th Grade	1996 8th Grade
Lowest-SES Black Students	6	28	11	43
Lowest-SES White Students	6	51	25	62
Highest-SES Black Students	10	41	25	56
Highest-SES White students	21	65	40	78

Table Note: The percentages given are row percents. For example, in 1990, 6% of Black students had teachers who allowed calculator use "almost every day." For both calculator-related variables, the 1996 overall SES and race-related differences are significant. The SES difference within White students is also significant, but the SES difference within Black students is not. (The relatively small sample of Black students is a factor here.)

Although most teachers reported that they do not use multiple choice tests often, 4th grade Black students of all SES levels were more likely than White students to be assessed with multiple choice assessments. For example, the teachers of 44% of White, versus 65% of Black 4th graders reported using multiple choice assessments at least monthly. High-SES White 4th graders appeared less likely to have multiple choice tests than their low-SES counterparts, but SES patterns were absent for Black 4th graders, with over 60% of Black students at each SES level experiencing regular multiple choice tests. SES and Black-White disparities were smaller but still present at the 8th grade level.

Teacher Beliefs and Emphases

As part of the 1996 NAEP, teachers were asked about the emphasis they place on a variety of mathematical topics. Might the particular trouble with measurement be due to differences in teacher emphases on measurement? Not according to teachers' reports about the emphasis they place on various topics. There was remarkable consistency across both student race and SES in terms of the emphasis teachers reported giving to each of the five strands[9]. The scale teachers were given to indicate their emphasis on a topic had four options: 1 = A lot of emphasis, 2 = some emphasis, 3 = a little emphasis, or 4 = none. The mean for measurement was very close to 2 (ranging between

[9] Still, as mentioned in a previous footnote, there were small but significant race- and SES-related differences in terms of 8th grade algebra emphasis.

1.95 and 2.06) for teachers of all Black and White SES groups. (In comparison, the means were between 1.06 and 1.15 for number, indicating that this receives more focus than measurement.)

Still, substantial differences in instructional emphases might be masked in these data. The 4 point scale is rough and perhaps insensitive to actual differences in teacher emphases. Also, the NAEP surveys do not delineate the particular topics taught within each strand. The results of the special NAEP theme assessment discussed above (Mitchell, Hawkins, Stancavage, & Dossey, 1999) indicate that White students could have more opportunities to learn some of the content advocated in the NCTM Standards.

However, despite the consistency in teachers' reported emphases on most general mathematical topics, teachers of lower-SES and minority 8th graders reported giving significantly less emphasis to "reasoning to solve unique problems." SES differences appeared to explain some, but not all, of this Black-White disparity in teacher emphasis on reasoning. The SES and Black-White disparities were significant and similar in size, but the mean for the highest-SES Black students was near the mean for the lowest-SES White students. These disparities in teacher emphasis could be linked to the fact that achievement gaps favoring higher-SES and White students appear to be greater on extended response tasks than on multiple choice items. Still, as will be discussed further below, this relationship cannot be assumed.

Discussion

By going beyond the traditional, isolated examination of race, class or gender, this study helps clarify the gaps in mathematics achievement. Although overall NAEP scores increased for both Black and White students between 1990 and 1996, the Black-White gap increased slightly for both low- and high-SES students at grade 8, and for low-SES students at grade 12. This increase at grade 12 appeared to be due to the scores of lower-SES Black males remaining steady between 1990 and 1996, while the other groups made considerable gains. The Black-White gaps in mathematics achievement are not simply due to student SES differences, as revealed by the fact that in both 1990 and 1996, the lowest-SES White students scored equal to or higher than the highest-SES Black students. The Black-White and SES gaps are particularly severe in the mathematical strands of measurement and data analysis, as well as on open-ended assessment items.

In addition to considering student performance data, this study also considered student attitudes and classroom practices to determine possible factors underlying the Black-White achievement gaps. This analyses uncovered more similarities than differences in students' mathematical experiences, with few race-related gaps found in the use of manipulatives, "real-life" mathematics problems, student collaboration, and time spent on homework or math instruction. Similarly no race-related differences were found in students' liking of mathematics, beliefs about the usefulness

of mathematics, nor about the likelihood that student efforts can produce mathematical success. Additionally, no differences were found in teachers' reported knowledge of the NCTM *Standards*.

Still, this study identified some race-related differences that could relate to Black-White achievement disparities. Student course taking is likely a factor, but appears more related to SES than race, and therefore leaves much of the Black-White achievement gap unexplained. Factors correlating with race that persist even after controlling for SES include students' belief that there is only one way to solve a math problem, the belief that learning mathematics is mostly memorizing facts, the use of computers for skill practice or games, limited calculator use, multiple choice assessment use, and lack of teacher emphasis on "reasoning to solve unique problems."

These findings recall Anyon's (1981) study in which lower-SES students were found to receive more authoritative, drill-based instruction, whereas higher-SES students were taught the problem solving and critical thinking skills necessary for leadership roles in society. The reasons for race-related differences in student beliefs and classroom experiences, as well as the effects of these differences, require further research.

There are also several limitations of this analysis. One potential underlying factor of race-related differences discussed here is school-level SES. Perhaps more mid-SES African American students are in relatively low-SES schools, and, therefore, some race-related differences that persist after controlling for student SES might be due to school SES. Another important caveat to note is that NAEP classroom practice data are based on teacher and student self-reports, and differences in question interpretations or perceived pressure to portray instruction in particular ways could have affected student and teacher responses to questions. Also, the instructional practices reported for each student are only those the student is encountering at the time the NAEP assessment is administered. Hence, students' experiences in previous years with other teachers are not reflected in the NAEP classroom practice data. Thus, although White and higher-SES students appear to have more of the beliefs and classroom experiences promoted by the NCTM Standards, we cannot conclude from NAEP data that Standards-based experiences are the *cause* of their higher achievement. For example, one alternative explanation is that teachers are more likely to implement open-ended practices with higher achieving students.

Elsewhere I have written about struggles faced by lower-SES students attempting to learn mathematics through problem solving and whole-class discussion (Lubienski, 2000a; 2000b). Although most of the students studied were White, the results raise questions about similar struggles that Black students might face with more open mathematics environments. Delpit (1986) raised similar issues about literacy education. These previous studies indicate that we cannot assume that simply implementing *Standards* based curricula and pedagogies without attention to the special strengths and needs of poor or minority students will alleviate these gaps. We need

continued research into ways of assisting African American and lower-SES children's' development as mathematical problem solvers.

Clearly, African American students' relatively high omit and failure rates on open-ended assessment items suggest that these students need more opportunities to develop complex problem solving skills. Indeed, Strutchens and Silver (2000) concluded that 1996 Black 8th graders performed only about 20% as well as White students on extended constructed-response tasks, while performing about 70% as well as White students on multiple-choice questions.[10] They raise the important possibility that we could see continued widening of the Black/White gap as complex, extended tasks become more prevalent on standardized assessments. In fact, this is one plausible explanation for why some Black-White gaps have begun to widen in the last decade. Further analyses of NAEP and other assessments can add to our understanding of trends in equity-related gaps, as well as the effects of varying question types and mathematical content on these gaps. For example, a recent TIMSS report revealed a narrowing of the Black-White gap for 1999 8th graders, (when compared with 4th graders tested four years earlier); meanwhile, gaps relating to parental education widened (US Department of Education, 2001). With NCTM's (2000) recent affirmation of its vision of mathematical power for all, it is particularly important that researchers continue to monitor and seek to address ethnicity- and class-based inequities in mathematics education.

Finally, on a more personal note, I entered this analysis with a main focus on SES, not race. However, the race-related achievement disparities that persisted even after controlling for SES made me shift my primary concern. This analysis highlights the importance of disentangling race, SES, and gender, because doing so can reveal ways in which various factors shape students' experiences and achievement.

REFERENCES

Anyon, J. (1981). Social class and school knowledge. Curriculum Inquiry, 11, 3-42.

Campbell, J. R., Hombo, C. M., Mazzeo, J. (2000). NAEP 1999 trends in academic progress: three decades of student performance. Washington, DC: U.S. Department of Education, Office of Educational Research and Improvement, National Center for Education Statistics.

Campbell, P. B. (1991). So what do we do with the poor, non-White female? Issues of gender, race, and social class in mathematics and equity. Peabody Journal of Education, 66, 95-112.

Delpit, L. D. (1986). Skills and other dilemmas of a progressive Black educator. Harvard Educational Review, 56(4), 379-385.

Jencks, C., & Phillips, P. (Eds.) (1998). The Black-White test score gap. Washington, DC: Brookings Institution Press.

Johnson, E. G. (1992). The design of the National Assessment of Educational Progress. Journal of Educational Measurement, 29(2) 95-110.

Johnson, E. G. & Rust, K. F. (1992). Population inferences and variance estimation for NAEP data. Journal of Educational Statistics, 17(2) 175-190.

Kenney, P. A. & Silver, E. A. (Eds.) (1997). Results from the sixth mathematics assessment of the National Assessment of Educational Progress. Reston, VA: National Council of Teachers of Mathematics.

[10] These percentages are derived using ratios of correct responses, as opposed to differences in percentages correct.

Knapp, M. S., Shields, P. M., & Turnbull, B. J. (1995). Academic challenge in high-poverty classrooms. Phi Delta Kappan, 76, 770-776.

Lubienski, S. T., & Bowen, A. (2000). Who's Counting? A Survey of Mathematics Education Research 1982-1998. Journal for Research in Mathematics Education, *31*(5), 626-633.

Lubienski, S. T. (2000a). A clash of class cultures? Students' experiences in a discussion-intensive seventh-grade mathematics classroom. Elementary School Journal, *100*, 377-403.

Lubienski, S. T. (2000b). Problem solving as a means toward "mathematics for all": An exploratory look through a class lens. Journal for Research in Mathematics Education, 31(4), 454-482.

Lubienski, S. T. (2001). Are the NCTM *Standards* reaching all students? An examination of race, class, and instructional practices. Paper presented at the annual meeting of the American Educational Research Association, Seattle.

Means, B. & Knapp, M. S. (1991). Cognitive approaches to teaching advanced skills to educationally disadvantaged students. Phi Delta Kappan, December, 282-289.

Mitchell, J. H., Hawkins, E. F., Stancavage, F. B., and Dossey, J. A. (1999). Estimation skills, mathematics-in-context, and advanced skills in mathematics, NCES 2000-451. Washington, DC: National Center for Education Statistics.

Mitchell, J. H., Hawkins, E. F., Jakwerth, P., Stancavage, F. B., & Dossey, J. A. (1999). Student work and teacher practices in mathematics, NCES 1999–453. Washington, DC: National Center for Education Statistics.

Moses, R. P. (1994). Remarks on the struggle for citizenship and math/science literacy. Journal of Mathematical Behavior, 13 107-111.

National Council of Teachers of Mathematics. (1989). Curriculum and evaluation standards for school mathematics. Reston, VA: Author.

National Council of Teachers of Mathematics. (1991). Professional standards for teaching mathematics. Reston, VA: Author.

National Council of Teachers of Mathematics, (1993). NAEP results show improvement. News Bulletin, 12, 1&12.

National Council of Teachers of Mathematics, (2000). Principles and standards for school mathematics. Reston, VA: NCTM.

Reese, C. M., Miller, K. E., Mazzeo, J., and Dossey, J. A. (1997). NAEP 1996 Mathematics report card for the Nation and the states. Washington, DC: National Center for Education Statistics.

Reyes, L.H., & Stanic, G. M. A. (1988). Race, sex, socioeconomic status, and mathematics. Journal for Research in Mathematics Education, 19(1), 26-43.

Secada, W. G. (1992). Race, ethnicity, social class, language, and achievement in mathematics. In D. A. Grouws (Ed.), Handbook of research on mathematics teaching and learning (pp. 623-660). New York: Macmillan.

Stiff, L. (1990). African-American students and the promise of the Curriculum and Evaluation Standards. In T. J. Cooney & C. R. Hirsch (Eds.), Teaching and learning mathematics in the 1990s (Yearbook of the National Council of Teachers of Mathematics, pp. 152-157), Reston, VA: NCTM.

Strutchens, M. E., & Silver, E. A. (2000). NAEP findings regarding race/ethnicity: Students' performance, school experiences, and attitudes and beliefs. In E. A. Silver & P. A. Kenney (Eds.), Results from the seventh mathematics assessment of the National Assessment of Educational Progress. Reston, VA: National Council of Teachers of Mathematics.

Tate, W. F. (1997). Race-ethnicity, SES, gender, and language proficiency in mathematics achievement: An update. Journal for Research in Mathematics Education, 28 , 652-679.

U.S. Department of Education. National Center for Education Statistics. Pursuing excellence; Comparisons of international eighth-grade mathematics and science achievement from a U.S. perspective, 1995 and 1999, NCES 2001–028, by Patrick Gonzales, Christopher Calsyn, Leslie Jocelyn, Kitty Mak, David Kastberg, Sousan Arafeh, Trevor Williams, and Winnie Tsen. Washington, DC: U.S. Government Printing Office, 2000.

TM032849

U.S. Department of Education
Office of Educational Research and Improvement (OERI)
National Library of Education (NLE)
Educational Resources Information Center (ERIC)

REPRODUCTION RELEASE

(Specific Document)

I. DOCUMENT IDENTIFICATION:

Title: A Second Look at Mathematics Achievement Gaps: Intersections of Race, Class & Gender in NAEP Data.	
Author(s): Sarah Theule Lubienski	
Corporate Source: Iowa State University.	Publication Date: 4/13/01

II. REPRODUCTION RELEASE:

In order to disseminate as widely as possible timely and significant materials of interest to the educational community, documents announced in the monthly abstract journal of the ERIC system, *Resources in Education* (RIE), are usually made available to users in microfiche, reproduced paper copy, and electronic media, and sold through the ERIC Document Reproduction Service (EDRS). Credit is given to the source of each document, and, if reproduction release is granted, one of the following notices is affixed to the document.

If permission is granted to reproduce and disseminate the identified document, please CHECK ONE of the following three options and sign at the bottom of the page.

The sample sticker shown below will be affixed to all Level 1 documents	The sample sticker shown below will be affixed to all Level 2A documents	The sample sticker shown below will be affixed to all Level 2B documents
PERMISSION TO REPRODUCE AND DISSEMINATE THIS MATERIAL HAS BEEN GRANTED BY _____ _____ TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC) 1	PERMISSION TO REPRODUCE AND DISSEMINATE THIS MATERIAL IN MICROFICHE, AND IN ELECTRONIC MEDIA FOR ERIC COLLECTION SUBSCRIBERS ONLY, HAS BEEN GRANTED BY _____ _____ TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC) 2A	PERMISSION TO REPRODUCE AND DISSEMINATE THIS MATERIAL IN MICROFICHE ONLY HAS BEEN GRANTED BY _____ _____ TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC) 2B
Level 1	Level 2A	Level 2B
☑	☐	☐
Check here for Level 1 release, permitting reproduction and dissemination in microfiche or other ERIC archival media (e.g., electronic) *and* paper copy.	Check here for Level 2A release, permitting reproduction and dissemination in microfiche and in electronic media for ERIC archival collection subscribers only	Check here for Level 2B release, permitting reproduction and dissemination in microfiche only

Documents will be processed as indicated provided reproduction quality permits.
If permission to reproduce is granted, but no box is checked, documents will be processed at Level 1.

I hereby grant to the Educational Resources Information Center (ERIC) nonexclusive permission to reproduce and disseminate this document as indicated above. Reproduction from the ERIC microfiche or electronic media by persons other than ERIC employees and its system contractors requires permission from the copyright holder. Exception is made for non-profit reproduction by libraries and other service agencies to satisfy information needs of educators in response to discrete inquiries.

Sign here, please	Signature: Sarah Theule Lubienski	Printed Name/Position/Title: Sarah Theule Lubienski / Asst. Professor	
	Organization/Address: Iowa State University, N131 Lago Ames, IA 50011	Telephone: 515-294-3351	FAX: 515-294-6206

	E-Mail Address:	Date:
	Stl@iastate.edu	4/19/01

III. DOCUMENT AVAILABILITY INFORMATION (FROM NON-ERIC SOURCE):

If permission to reproduce is not granted to ERIC, *or*, if you wish ERIC to cite the availability of the document from another source, please provide the following information regarding the availability of the document. (ERIC will not announce a document unless it is publicly available, and a dependable source can be specified. Contributors should also be aware that ERIC selection criteria are significantly more stringent for documents that cannot be made available through EDRS.)

Publisher/Distributor:
Address:
Price:

IV. REFERRAL OF ERIC TO COPYRIGHT/REPRODUCTION RIGHTS HOLDER:

If the right to grant this reproduction release is held by someone other than the addressee, please provide the appropriate name and address:

Name:
Address:

V. WHERE TO SEND THIS FORM:

Send this form to the following ERIC Clearinghouse:

However, if solicited by the ERIC Facility, or if making an unsolicited contribution to ERIC, return this form (and the document being contributed) to:

ERIC Processing and Reference Facility
4483-A Forbes Boulevard
Lanham, Maryland 20706

Telephone: 301-552-4200
Toll Free: 800-799-3742
FAX: 301-552-4700
e-mail: ericfac@inet.ed.gov
WWW: http://ericfac.piccard.csc.com

EFF-088 (Rev. 2/2000)