

Introduction

Student responses to MDTP test items given by the Los Angeles Community College District during the 1990-1991 academic year are analyzed to determine possible differential item functioning. The gender and ethnicity of the students were self-reported. The analysis is based upon the Mantel-Haenszel procedure that has been used at the Educational Testing Service. This report begins with a brief discussion of the methodology, including some of the limitations that were followed in this study. A summary and discussion of the findings for the four tests studied follows. The report concludes with tables of the Mantel-Haenszel D-DIF statistics and corresponding p-values for the populations studied.

The Procedure

The possible differential item functioning between two populations will be measured by statistics computed using the Mantel-Haenszel procedure as described in Holland and Thayer (1988). In each comparison, the two populations studied are called the reference group and the focal group. Each population is further divided into sets based upon performance on the entire test. The item performance of each matched set from the two groups is compared by an odds-ratio defined later. The Mantel-Haenszel estimate of the common odds-ratio measure of differential item functioning is a weighted average, $\hat{\theta}$, of the odds-ratios estimates for the matched sets. Finally that estimate is transformed by a logarithm to convert it to an estimate, $\hat{\delta}$, of differential item functioning in the scale of item difficulty as measured in the ETS "delta scale". $\hat{\delta}$ is also called the Mantel-Haenszel delta difference or MH D-DIF in the literature. As reported in Ryan (1991), ETS classifies those items for which $|\hat{\delta}| \geq 1.5$ and for which $\hat{\delta}$ is significantly greater than 1.0 as "C" items and chooses them only if needed to meet test specifications. In this report those items for which $|\hat{\delta}| \geq 1.5$ will be referred to as C-candidates and will receive special attention.

The odds-ratio within each matched set is estimated as follows. The numbers of members of each group who answered the item correctly and incorrectly are found. We will use the notation suggested by the following table. (For those familiar with the Holland-Thayer note, we point out that their A_j, B_j, C_j, D_j correspond to our $R1_j, R0_j, F1_j, F0_j$ respectively.)

j^{th} Matched Set from	Number with Correct Response	Number with Incorrect Response
Reference Group	R_{1j}	R_{0j}
Focal Group	F_{1j}	F_{0j}

The total number of members in the j^{th} matched set from both groups is T_j . The odds-ratio is the factor by which the odds that a reference group member answers an item correctly exceeds the odds that a focal group member (of equal “ability” as measured by total test score) answers that item correctly. A straightforward estimate of the odds-ratio of the reference group to the focal group in the j^{th} matched set is $\hat{\omega}_j = \frac{R_{1j}/R_{0j}}{F_{1j}/F_{0j}} = \frac{R_{1j} \times F_{0j}}{R_{0j} \times F_{1j}}$.

The Mantel-Haenszel estimate of differential item functioning is the weighted average of these estimates where $\hat{\omega}_j$ is weighted by $w_j = \frac{R_{0j} \times F_{1j}}{T_j}$. Thus,

$$\hat{\omega} = \frac{\sum_j \hat{\omega}_j \times w_j}{\sum_j w_j} = \frac{\sum_j \frac{R_{1j} \times F_{0j}}{T_j}}{\sum_j \frac{R_{0j} \times F_{1j}}{T_j}}. \text{ The last form is used in the computation of}$$

this statistic. Finally, following Holland and Thayer, the estimated measure of differential item functioning used is $\hat{\delta} = -\frac{4}{1.7} \ln(\hat{\omega})$. A negative value of $\hat{\delta}$ indicates that the item may be easier for the reference group than for the focal group. In the middle of the ETS delta scale, an absolute value of 1 for $\hat{\delta}$ is considered to be approximately a 10% difference in item difficulty according to Kubiak & Colwell (1990, April). We note here that the roles of the focal group and the reference group are symmetric since interchanging them simply inverts $\hat{\omega}$ and therefore only changes the sign of $\hat{\delta}$.

As suggested by Kubiak & Colwell, two constraints were followed in this study to avoid unreliable data. Population groups had to contain at least 100 members. Matched sets were only counted if the expected frequency of each of the four numbers in the table was at least five. To reduce the number of cases that could not be counted, students were grouped by intervals of test scores rather than by a single test score. There is some discussion of this methodology in Raju (1989). For the two fifty item tests the five score intervals used were 0–10, 11–20, 21–30, 31–40, and 41–50. For the forty-five item test, the five score intervals used were 0–9, 10–18, 19–27, 28–36, and 37–45. The eight score intervals used for the forty item test were 0–5, 6–10, 11–15, 16–20, 21–25, 26–30, 31–35, and 36–40.

The Populations and Tests Studied

This report presents an analysis of student responses to four tests developed by the California Mathematics Diagnostic Testing Project (MDTP). These tests are those most commonly used at California community colleges. The four tests are listed, along with their abbreviations to be used throughout this report and the specific form of each test, in the following table.

Abbreviation	Test	Form
AR	Algebra Readiness	AR50/86
EA	Elementary Algebra	EA50C86
IA	Intermediate Algebra	IA45C86
PC	Precalculus	PC40C86

All students whose item responses were analyzed in this study were given MDTP tests at six community colleges within the Los Angeles Community College District during the 1990-1991 academic year. The district, which has a diverse student population, administers tests in roughly the same proportion as tests are administered throughout the California community colleges. Their gender and ethnicity were self-reported. The ethnic classifications used in this study are Asian (A), Black (B), Hispanic (H), and White (W). The numbers of students reporting other ethnicities were too small to provide reliable data for the Mantel-Haenszel procedure. The number of students in each category for each test is reported in the following tables. The Black student group was not used for ethnic comparisons in the Precalculus test because of the small number of cases available. While comparisons were done with the Black student group for the Intermediate Algebra test, we caution that the number of cases is marginal for the analysis.

Test	AR	EA	IA	PC
Sex				
Female (F)	5,129	1,391	652	168
Male (M)	3,781	1,520	775	391
Total	8,910	2,911	1,427	559

Test	AR	EA	IA	PC
Ethnicity				
Asian (A)	918	435	336	567
Black (B)	1,101	337	132	60
Hispanic (H)	4,261	1,048	394	190
White (W)	1,885	756	352	278
Total	8,165	2,576	1,214	1,095

Most of the discrepancies between the two tables in the total numbers of students come from students who reported other ethnicities than the four used in this

study. In the case of the Precalculus test, we realized that the numbers of cases in the ethnic groups were too small after running the gender comparisons. We then obtained data from the following year, which were combined with the data previously available. This is why there are almost twice as many cases in the ethnic comparisons than in the gender comparisons for the Precalculus test.

Summary of Results

The values of $\hat{\Delta}$ for each available comparison are listed in the first five tables in the Appendix to this report. In the table giving the results for all tests comparing groups by gender, the column heads are the test abbreviations. In each of these comparisons females were the reference group and males the focal group. In every other case, the column listing the estimates is headed by abbreviations for the groups being compared, with the abbreviation for the reference group listed before that for the focal group. Each list of $\hat{\Delta}$ values is followed by the mean and standard deviation of those values. The last four tables in the Appendix list the proportion of each ethnic group correctly responding to each item on each of the tests. Those few items for which $\hat{\Delta}$ is not listed in some tables lacked enough data to compute the estimate.

Recall that negative values of $\hat{\Delta}$ indicate that an item may be easier for the reference group than for the focal group. Recall also that items of most concern for differential functioning between groups are those whose $\hat{\Delta}$ is greater than or equal to 1.5 or less than or equal to -1.5 . These are the items that we refer to as C-candidates in this report.

Table One, reporting the Mantel-Haenszel estimate of DIF on the ETS “delta” scale for groups determined by gender, shows that no items on any of the tests have $|\hat{\Delta}| \geq 1.5$. The results for comparisons of ethnic groups are reported in successive tables for the different MDTP tests and are summarized in following paragraphs of this section. In particular, the numbers of items in each ethnic comparison for which $\hat{\Delta} \geq 1.5$ and those for which $\hat{\Delta} \leq -1.5$ are tabulated. There is brief discussion of some observed patterns in the ethnic comparisons.

Algebra Readiness Test

The numbers of items that are C-candidates in each of the ethnic comparisons for the Algebra Readiness test are listed in the following table.

	AB	AH	AW	BW	HW	BH
$\hat{}$ 1.5	6	5	6	2	3	0
$\hat{}$ -1.5	6	8	10	0	0	0

The number of C-candidates common to all comparisons between Asians and the other ethnic groups is reasonably balanced between those which appear harder and those which appear easier for Asians. Nine items appear as C-candidates in all three ethnic comparisons involving Asians, four being consistently more difficult for Asians and five less difficult for Asians. All four of the more difficult candidates are verbally loaded: one involves interpretation of a data graph; two involve interpreting a verbally presented situation to do some computation or estimation; and the fourth concerns distance on the number line presented without a figure. All five of the easier candidates require computation and no interpretation: two require addition of fractions; one involves iterated subtraction of integers; and the remaining two require simplification of terms involving literal symbols and two operations. The Asian p-values were much higher than those of the other ethnicities for all of the items which are candidates for being easier for Asians; for example the item 28 p-value for Asians is .77, which is .21 higher than the p-value for Whites and .33 and .32 higher than those for Blacks and Hispanics respectively.

For the Algebra Readiness test, we recomputed the estimates $\hat{}$ for the first two comparisons, AB and AH, with a larger number of matched sets, to see whether the same patterns would appear. We selected the scoring intervals to make the mean total scores in the matched groups as similar as we could. The intervals used were 0–7, 8–13, 14–19, 20–25, 26–31, 32–37, 38–43, and 44–50. Among the C-candidates, in the AB comparison, three of the apparently easier items for Asians dropped from that list (items 31, 33, and 43). In the AH comparison, four of the apparently easier items for Asians lost their C-candidate standing (items 18, 21, 42, and 43), one of the apparently harder items (item 30) no longer satisfied the $\hat{}$ 1.5 criterion, but a different item (item 12) did.

We also looked at the B-candidates, $1.0 \leq \hat{} < 1.5$, for the three Algebra Readiness ethnic comparisons involving Asians. All items which by this criteria appeared harder for Asians were verbally loaded, requiring understanding of wording or mathematical terminology. No items which by this criteria appeared easier for Asians were verbally loaded and two-thirds to four-fifths of these items were strict computations involving no words.

Elementary Algebra Test

The numbers of items that are C-candidates in each of the ethnic comparisons for the Elementary Algebra test are listed in the following table.

	AB	AH	AW	BW	HW	BH
$\hat{}$ 1.5	1	1	4	0	2	0
$\hat{}$ -1.5	2	3	2	0	0	0

Item 34, which appears significantly harder for Asians than for any other ethnic group, is a heavily verbally loaded item, asking for the minimum of the three consecutive integers whose sum is 36. On the other hand, item 40, which appears significantly easier for Asians than for any other ethnic group, is a purely computational item asking for the sum of two rational expressions involving literals. Moreover, the p-value for this item for Asians, .39, is at least three times as large as that for any other ethnic group. Item 19, which appears somewhat easier for Whites than Asians or Hispanics, is verbally loaded, but then requires solving a simple linear equation.

Intermediate Algebra Test

The numbers of items that are C-candidates in each of the ethnic comparisons for the Intermediate Algebra test are listed in the following table.

	AB	AH	AW	BW	HW	BH
$\hat{}$ 1.5	1	1	1	1	1	1
$\hat{}$ -1.5	0	2	1	0	1	1

Since item 43 is a C candidate in four of the five comparisons that could be made among ethnic groups, and since item 41 may be significantly easier for Whites than for Asians or Hispanics, we discuss them briefly. Both are verbally loaded. Item 43 was a very difficult item, with an overall p-value of .17 and p-values for both Blacks and Hispanics .11. These small p-values suggest that the estimates may be largely due to chance. Similarly, item 41 was a difficult item, with an overall p-value of .20.

Precalculus Test

The numbers of items that are C-candidates in each of the ethnic comparisons for the Precalculus test are listed in the following table.

	AH	AW	HW
$\hat{}$ 1.5	0	1	5
$\hat{}$ -1.5	1	0	0

The estimates $\hat{}$ of two of the items (4 and 16) that are C-candidates in the HW comparison are not even significantly different from zero; for one only one small matched group could be used in computing the estimate while two small

matched groups were available for the other. Three of the five items that may be significantly harder for Hispanic students than for White students also may be marginally more difficult, $1 - |\hat{\theta}| < 1.5$, for Hispanic students than for Asian students. All three of these items are mildly sophisticated computations, the first requiring solving a system of two linear equations in two unknowns, the second being the evaluation of a logarithm to base 2, and the third asking for simplifying an rational expressions with variables. None of these three items appear verbally loaded.

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Appendix

Table One
MH D-DIF on Gender

	AR	EA	IA	PC
I1	.11	.08	-.10	-.30
I2	-.65	-.36	-.47	.12
I3	-.37	.57	-.05	-1.49
I4	-.28	.35	-.02	-.41
I5	.33	-.06	.08	.71
I6	.35	.11	.01	-.55
I7	-.02	.42	.37	-1.08
I8	.53	-.23	-.40	-.50
I9	1.01	.18	.53	-.61
I10	.73	.36	.32	-.08
I11	-.46	-.45	-.37	-.42
I12	.10	-.08	-.07	-.13
I13	.12	-.32	.03	-.38
I14	-.26	.11	.24	.06
I15	-.49	-.42	-.56	-.12
I16	.27	-.11	-.64	-.26
I17	-.63	-.15	-.18	-.91
I18	-.04	.48	-.60	.69
I19	1.23	.64	.04	-.80
I20	-.06	.35	.03	.03
I21	-.05	1.10	.08	.47
I22	.25	-.63	.03	-.65
I23	.06	-.92	.91	.20
I24	-.13	-.71	-.22	-.46
I25	-.26	-.30	-.42	.13
I26	-.53	.79	.00	-.12
I27	.18	-.45	.23	-1.75
I28	-.79	-.19	-.44	.79
I29	-.09	-.71	-.43	.36
I30	.56	-.51	.61	.09
I31	-.02	.45	-.78	-.35
I32	.21	.25	1.10	.57
I33	-.27	-.58	-.11	-.03
I34	.13	.61	-.21	-.54
I35	.25	-.97	.24	.01
I36	.29	-.33	-.56	-.17
I37	.88	-.42	.64	.63
I38	.03	-.47	.47	-.67
I39	.68	-.15	-.95	.69
I40	-.25	-.98	-.11	.66
I41	.06	.40	.80	
I42	-.27	.39	-.76	
I43	-.78	1.10	-.35	
I44	.28	-.78	.14	
I45	-.11	.27	-1.06	
I46	.10	.10		
I47	.11	-.18		
I48	.03	-.18		
I49	.30	.73		
I50	.01	.13		
MEAN	.048	-.033	-.066	-.164
SD	.429	.518	.481	.592

Table Two
MH D-DIF for Algebra Readiness on Ethnicity

	AB	AH	AW	BW	HW	BH
I1	-1.63	-.71	.25	1.89	1.02	.81
I2	-.95	-1.70	-1.40	-.39	.31	-.71
I3	-1.44	-.64	-.43	1.03	.24	.82
I4	-.93	-.44	.36	1.17	.88	.27
I5	2.09	2.38	2.11	.67	-.25	.10
I6	3.36	2.67	4.95	1.42	2.37	-.92
I7	-1.41	-.88	-.35	1.04	.51	.51
I8	1.44	1.40	2.09	1.50	.76	-.29
I9	1.61	1.54	2.91	1.25	1.45	-.20
I10	-.61	-.48	.53	1.07	.96	.12
I11	-.43	-.55	-.98	-.56	-.41	-.11
I12	1.55	1.45	1.25	-.60	-.43	-.08
I13	1.55	1.51	.58	-.93	-.84	-.17
I14	.22	-.32	.69	.56	1.02	-.45
I15	.18	-.33	.42	.24	.70	-.43
I16	-.15	.13	.89	1.08	.72	.35
I17	-1.19	-1.14	-1.52	-.20	-.30	.10
I18	-1.30	-1.54	-.75	.59	.79	-.18
I19	1.44	1.20	2.43	.70	1.16	-.45
I20	1.27	.96	.34	-.95	-.66	-.23
I21	-2.36	-1.62	-2.21	.22	-.53	.76
I22	.08	.05	.03	-.30	-.22	-.07
I23	.44	.22	.10	-.60	-.32	-.24
I24	-.95	-1.03	-1.78	-.84	-.77	-.08
I25	-.33	-.13	-1.07	-.56	-.62	.03
I26	-1.39	-.78	-.62	.79	.15	.69
I27	-.99	-.30	-1.32	-.30	-1.00	.66
I28	-2.56	-2.07	-2.44	.24	-.38	.58
I29	-1.43	-1.12	-1.70	.00	-.39	.28
I30	2.01	1.91	2.70	.29	.62	-.31
I31	-1.52	-1.81	-1.78	-.11	.10	-.24
I32	1.15	1.17	.97	-.43	-.38	.00
I33	-1.66	-2.08	-2.42	-.57	-.28	-.32
I34	-.67	-.46	-1.35	-.31	-.65	.32
I35	.77	.90	.91	.24	.09	.17
I36	-.45	.00	-1.23	-.81	-1.26	.43
I37	-1.09	-1.45	.22	1.22	1.53	-.31
I38	.39	.74	.35	-.63	-.76	.04
I39	-.40	-.18	-.22	.53	.08	.52
I40	-.08	-.36	-.91	-.46	-.30	-.14
I41	-.79	-1.16	-1.55	-.53	-.31	-.16
I42	-1.08	-1.53	.18	1.16	1.56	-.38
I43	-1.61	-1.77	-1.54	.14	.25	-.08
I44	-.27	-.32	.73	1.14	1.17	-.06
I45	-.69	-1.07	-1.48	-.74	-.49	-.15
I46	.86	.55	.49	.01	.13	-.26
I47	.22	-.52	.12	-.10	.63	-.71
I48	-.07	-.88	-.80	-.41	.19	-.55
I49	-.23	-.34	.07	.18	.26	-.05
I50	-.30	-1.25	-1.60	-1.01	-.33	-.43
MEAN	-.217	-.244	-.096	-.024	.161	.155
SD	1.248	1.175	1.504	.409	.770	.771

Table Three
MH D-DIF for Elementary Algebra on Ethnicity

	AB	AH	AW	BW	HW	BH
I1	-.64	-.19	-.25	.25	-.06	.34
I2	-.93	-.96	-.43	.56	.56	-.03
I3	-.10	-.74	.69	.64	1.42	-.78
I4	-.44	.02	-.41	.13	-.24	.21
I5	-1.12	-1.13	-.65	.52	.46	.13
I6	-.87	-.38	-.90	-.05	-.52	.51
I7	-.71	-.08	.75	1.28	.75	.51
I8	-.49	-.93	-1.15	-.62	-.19	-.51
I9	.23	.93	.65	.29	-.33	.65
I10	-.07	.32	-.31	-.04	-.44	.37
I11	.22	-.03	-.70	-.83	-.63	-.24
I12	-.20	.24	-.83	-.73	-1.05	.41
I13	.67	.37	-.72	-1.38	-1.08	-.29
I14	-.21	.17	-.31	.07	-.36	.51
I15	-1.09	-1.19	-.47	.70	.79	-.10
I16	-1.82	-.99	-.89	.81	.21	.65
I17	.61	.55	.45	-.50	-.34	.01
I18	.06	-.04	.26	.12	.30	-.26
I19	1.15	.63	2.09	.43	1.53	-1.26
I20	-.10	.13	.75	.84	.67	.16
I21	.21	.01	.88	1.08	1.05	-.14
I22	-.31	.19	-.57	-.35	-.84	.51
I23	-.37	-.05	-.72	-.59	-.79	.43
I24	-.52	-.13	-1.34	-.93	-1.23	.22
I25	-.34	.52	-.19	-.10	-.72	.65
I26	-.38	.02	.64	1.06	.60	.36
I27	-.96	-.11	.45	1.37	.57	.81
I28	-.84	-.07	-.64	.11	-.60	.62
I29	-1.18	-.29	-.83	.44	-.37	.62
I30	-.60	-.69	-.71	-.01	.05	-.08
I31	.51	.99	1.91	1.23	1.00	-.04
I32	-1.42	-1.31	-1.36	.34	-.03	.40
I33	-1.11	.08	-1.26	-.35	-1.49	1.16
I34	2.44	2.63	3.25	.59	.71	-.17
I35	-.04	.38	-.70	-.24	-.89	.64
I36	-.37	-.97	-.78	-.44	.15	-.69
I37	-.96	-.69	-1.15	-.33	-.51	.03
I38	.05	-.17	-.39	-.61	-.33	-.26
I39	-.61	-.12	-.40	.10	-.24	.19
I40	-2.25	-2.30	-2.95	-.61	-.56	-.05
I41	.13	.07	1.03	.82	.98	-.21
I42	-.63	-.59	-.48	.38	.12	.31
I43	-.65	-1.62	-.09	.66	1.58	-.91
I44	-1.40	-1.48	-1.51	-.17	-.09	.02
I45	-.23	.18	.57	.70	.34	.12
I46	-.06	.05	-.39	-.52	-.37	-.41
I47	.29	-.39	.98	.35	1.11	-.71
I48	-1.34	-1.60	-.61	.92	.97	-.16
I49	1.21	.19	1.62	.17	1.26	-1.00
I50	-.32	-1.16	-.50	-.97	.37	-.94
MEAN	-.358	-.235	-.172	.046	.132	.065
SD	.797	.809	1.050	.521	.649	.764

Table Four
MH D-DIF for Intermediate Algebra on Ethnicity

	AB	AH	AW	BW	HW	BH
I1	.26	-.33	.52	.71	1.22	-.92
I2	-.58	.08	-.76	-.08	-.73	.47
I3	.49	-.91	-.55	-.58	.67	-.74
I4	-.41	-.42	-.45	.21	.34	.01
I5	-.50	-.96	-1.00	-.56	-.06	-.61
I6	-.36	-.84	-.77	-.53	.04	-.60
I7	1.41	1.15	1.23	.23	.22	-.10
I8	.39	-.03	.51	.27	.36	.15
I9	-.47	-.07	.52	.94	.62	.53
I10	-1.06	-.62	-.68	.37	-.09	.39
I11	-1.12	-1.00	-1.71	-1.13	-.69	.80
I12	-.28	-.43	-.13	.07	.27	-.18
I13	-.10	-.01	-.29	-.26	-.05	-.40
I14	-.79	-.48	-.18	.25	.22	-.04
I15	-1.33	.07	-1.24	-.06	-1.44	1.52
I16	.57	.11	.12	-.36	.12	-.40
I17	.35	.13	-.34	-.20	-.28	.06
I18	.71	-.48	-.19	-.60	.49	-.98
I19	.89	.31	.55	-.94	-.05	-.33
I20	1.47	.69	.03	-1.25	-.61	-.56
I21	-.57	-.20	-.60	.06	-.36	.38
I22	-1.28	-.47	-.58	.86	.02	.77
I23	-.81	-.35	-.39	.41	-.08	.57
I24	-.73	-.27	-1.17	-.58	-.72	.17
I25	.68	.07	-.34	-.65	-.09	-.73
I26	-1.04	-1.28	-.30	.61	.86	-.01
I27	.23	.26	-.29	-.67	-.69	.25
I28	.85	-.10	-.51	-1.10	-.08	-.71
I29	-1.44	-.65	-.78	1.04	.23	.76
I30	-1.39	-.41	.64	1.21	.73	.37
I31	1.12	.16	-.71	-1.29	-.61	-.90
I32	-.50	-.22	.21	.50	.36	.05
I33	-.06	-.09	-.13	.35	.14	.15
I34	.03	.19	-.56	-.72	-.82	.18
I35	.38	-.62	-.17	-1.02	.82	-.86
I36	.58	.07	-.36	-1.33	-.71	-.66
I37	-.29	-.80	-.21	-.18	.48	-.63
I38	-.14	-1.72	-.50	-.31	1.21	-1.16
I39	-1.29	-1.63	.21			
I40	.31	-.30	-.47			
I41	1.23	-.41	1.53	.95	2.16	-.89
I42	-.18	-.21	.00	.35	.19	.35
I43	2.20	1.82	.64	1.71	-2.48	
I44	1.17	-.89	-.20	-.18	.84	-1.62
I45	-.62	-.44	.56			
MEAN	-.064	-.253	-.240	-.204	-.108	.144
SD	.816	.652	.702	.735	.694	.692

Table Five
MH D-DIF for Precalculus on Ethnicity

	AH	AW	HW
I1	1.20	.66	-.42
I2	.73	-.09	-.24
I3	.54	-.74	-.51
I4	-1.22	-.04	2.35
I5	-.48	-.10	.52
I6	-.57	-.50	-.25
I7	1.08	.26	-.17
I8	-1.73	-1.47	.67
I9	-.59	-1.32	-.50
I10	-.63	-.28	.27
I11	-1.36	-1.47	.12
I12	.79	.59	.34
I13	.97	-.56	-.93
I14	.99	1.62	.79
I15	-.37	-.10	.44
I16	-.36	.94	1.74
I17	.24	-1.15	-.81
I18	.84	.76	.18
I19	.53	.97	-.55
I20	.56	1.11	.82
I21	-.49	.88	1.67
I22	.62	.38	-.37
I23	.97	1.16	.06
I24	-.42	-.19	-.12
I25	.62	.31	.06
I26	.81	.41	-1.18
I27	-1.37	.00	1.62
I28	-.30	-.60	-.11
I29	-.37	-.58	.03
I30	-1.35	-.95	.21
I31	.14	.23	.24
I32	-.22	-.12	-.67
I33	.66	-.67	-1.11
I34	-.96	.23	.99
I35	-1.29	-.06	1.55
I36	.75	.47	.94
I37		1.06	
I38		1.04	
I39	-.02	-.71	-.73
I40	-.38	.18	.59
Mean	-.038	.039	.198
SD	.833	.774	.839

Table Six
p-values for Algebra Readiness on Ethnicity

	A	B	H	W
I1	.79	.56	.60	.78
I2	.75	.55	.45	.61
I3	.78	.57	.60	.72
I4	.70	.50	.48	.68
I5	.68	.77	.76	.81
I6	.28	.44	.34	.65
I7	.82	.62	.63	.77
I8	.74	.77	.73	.84
I9	.47	.48	.43	.67
I10	.76	.60	.58	.75
I11	.63	.47	.43	.50
I12	.17	.17	.15	.19
I13	.50	.53	.49	.51
I14	.73	.60	.53	.73
I15	.71	.57	.50	.69
I16	.64	.50	.51	.67
I17	.63	.40	.38	.46
I18	.60	.33	.29	.48
I19	.44	.43	.37	.58
I20	.51	.48	.43	.49
I21	.63	.29	.31	.41
I22	.52	.40	.37	.47
I23	.38	.29	.25	.33
I24	.55	.32	.29	.35
I25	.48	.32	.30	.34
I26	.65	.38	.41	.54
I27	.50	.26	.28	.33
I28	.77	.44	.45	.56
I29	.60	.33	.32	.43
I30	.31	.38	.33	.50
I31	.56	.29	.26	.35
I32	.51	.50	.47	.54
I33	.57	.28	.23	.34
I34	.34	.16	.16	.20
I35	.45	.39	.38	.48
I36	.48	.28	.29	.31
I37	.38	.16	.13	.32
I38	.30	.24	.23	.26
I39	.30	.14	.15	.23
I40	.47	.29	.25	.33
I41	.36	.18	.16	.20
I42	.37	.14	.12	.30
I43	.39	.14	.13	.23
I44	.32	.17	.15	.31
I45	.38	.19	.17	.21
I46	.16	.12	.11	.14
I47	.33	.21	.15	.28
I48	.24	.10	.07	.14
I49	.27	.13	.12	.20
I50	.29	.15	.12	.15

Table Seven
p-values for Elementary Algebra on Ethnicity

	A	B	H	W
I1	.77	.61	.64	.72
I2	.82	.62	.63	.75
I3	.51	.38	.32	.52
I4	.63	.41	.44	.52
I5	.70	.42	.44	.57
I6	.57	.26	.32	.41
I7	.71	.49	.54	.71
I8	.43	.17	.16	.26
I9	.74	.59	.65	.73
I10	.60	.37	.42	.48
I11	.48	.25	.27	.33
I12	.73	.49	.52	.59
I13	.56	.37	.35	.40
I14	.73	.49	.54	.62
I15	.84	.61	.61	.77
I16	.59	.24	.30	.43
I17	.59	.50	.50	.55
I18	.67	.50	.49	.61
I19	.40	.36	.27	.50
I20	.74	.59	.62	.75
I21	.31	.17	.19	.33
I22	.49	.25	.30	.33
I23	.63	.38	.42	.48
I24	.62	.36	.39	.41
I25	.28	.12	.16	.19
I26	.57	.31	.37	.54
I27	.77	.50	.59	.75
I28	.67	.35	.41	.51
I29	.60	.29	.36	.45
I30	.67	.39	.39	.52
I31	.31	.20	.21	.37
I32	.45	.13	.18	.25
I33	.47	.15	.23	.28
I34	.37	.37	.37	.56
I35	.35	.14	.18	.21
I36	.49	.26	.22	.32
I37	.63	.35	.37	.44
I38	.51	.31	.30	.38
I39	.46	.22	.24	.34
I40	.39	.07	.09	.13
I41	.45	.29	.29	.46
I42	.61	.39	.41	.50
I43	.39	.16	.14	.29
I44	.46	.17	.17	.26
I45	.44	.23	.25	.37
I46	.28	.19	.19	.19
I47	.34	.21	.18	.33
I48	.50	.19	.20	.35
I49	.38	.32	.25	.44
I50	.32	.13	.12	.19

Table Eight
p-values for Intermediate Algebra on Ethnicity

	A	B	H	W
I1	.77	.66	.59	.76
I2	.74	.50	.56	.61
I3	.76	.55	.51	.68
I4	.73	.50	.56	.67
I5	.65	.39	.35	.47
I6	.87	.73	.71	.80
I7	.52	.36	.36	.50
I8	.69	.48	.49	.63
I9	.58	.34	.40	.55
I10	.85	.61	.66	.73
I11	.54	.16	.25	.30
I12	.63	.46	.45	.55
I13	.73	.58	.57	.68
I14	.75	.45	.49	.64
I15	.74	.44	.59	.59
I16	.75	.58	.56	.67
I17	.52	.26	.25	.36
I18	.56	.33	.27	.43
I19	.59	.55	.53	.57
I20	.41	.29	.25	.29
I21	.62	.36	.40	.47
I22	.44	.20	.24	.30
I23	.57	.36	.43	.47
I24	.74	.44	.53	.57
I25	.57	.33	.30	.43
I26	.52	.22	.24	.39
I27	.41	.20	.20	.26
I28	.53	.33	.30	.39
I29	.62	.27	.33	.46
I30	.57	.35	.39	.57
I31	.36	.11	.12	.17
I32	.69	.45	.46	.64
I33	.44	.19	.19	.30
I34	.44	.25	.28	.29
I35	.38	.15	.13	.24
I36	.32	.16	.15	.19
I37	.50	.22	.21	.35
I38	.56	.31	.24	.39
I39	.35	.09	.09	.14
I40	.26	.09	.10	.14
I41	.24	.12	.11	.27
I42	.44	.20	.22	.32
I43	.18	.11	.10	.26
I44	.34	.14	.11	.22
I45	.23	.03	.03	.11

Table Nine
p-values for Precalculus on Ethnicity

	A	H	W
I1	.74	.62	.78
I2	.85	.75	.83
I3	.83	.67	.78
I4	.89	.67	.87
I5	.83	.61	.82
I6	.81	.58	.75
I7	.83	.68	.82
I8	.68	.29	.51
I9	.81	.54	.68
I10	.75	.52	.70
I11	.80	.53	.70
I12	.80	.63	.79
I13	.74	.53	.65
I14	.68	.48	.76
I15	.68	.44	.64
I16	.83	.67	.85
I17	.72	.52	.60
I18	.61	.43	.64
I19	.44	.27	.46
I20	.54	.37	.58
I21	.50	.23	.49
I22	.67	.52	.67
I23	.42	.32	.46
I24	.63	.35	.53
I25	.53	.34	.49
I26	.58	.41	.53
I27	.59	.23	.54
I28	.52	.26	.38
I29	.70	.39	.60
I30	.71	.35	.62
I31	.55	.24	.50
I32	.62	.34	.52
I33	.47	.18	.33
I34	.60	.23	.55
I35	.60	.21	.51
I36	.52	.19	.46
I37	.32	.12	.30
I38	.29	.09	.28
I39	.47	.22	.35
I40	.47	.17	.38

Because of the large number of items on the Algebra Readiness test that were identified as C-candidates in comparisons involving Asians, additional consideration has been given to those comparisons. All of the items that appeared to be harder for Asian students were verbally loaded. We understand that similar performance patterns have been observed in studies of entering students taking the Entry Level Mathematics Test for The California State University. This pattern is not unexpected since community college teachers report that entering community college students who are Asian and have not completed a first year algebra course often have easily recognized difficulties with English.

In view of the nature and cause of the apparent differential item functioning of verbally loaded items for Asian students, six of the C-candidate items that appeared more difficult for them were removed from the performance criteria used to form matched sets of students for the Mantel-Haenszel analysis. The rationale for this change is that for entering college Asian students those items appear to measure language limitations rather than mathematical preparation and ability. Their inclusion as performance criteria may skew the comparison on other items.

The six items removed from the scoring to determine performance criteria for the Mantel-Haenszel analysis were items 5, 6, 9, 13, 19, and 30. The eleven score intervals used were 0-4, 5-8, 9-12, ... , 37-40, and 41-44. When the analysis was redone on all fifty test items, the number of items that are C-candidates in each of the ethnic comparisons involving Asian students for the Algebra Readiness test are listed in the following table.

	AB	AH	AW
$\hat{}$ 1.5	10	5	7
$\hat{}$ -1.5	2	1	3

Only fourteen test items are represented in the above table due to duplication of some items in more than one column. More items were found to be C-candidates that were harder for Asian students than in the previous analysis. All of these items have a significant verbal component; most are verbally loaded while a few require an understanding of some mathematical terminology such as “least common multiple” or “approximation”. Since the comparison criteria did not include those items that had the most significant effect based on verbal difficulties, the increase in C-candidates of this type was expected and is reasonable given the experience of teachers with these students. Of more interest and significance for this study, there was a large decrease in the number of items that are now C-candidates for being easier for Asian students. Indeed, only three items on the test are now C-candidates of this type.

It is important to note that performance on verbally loaded items is still relevant to determining readiness for algebra courses taught in English. Eliminating this type of item could lead to placement recommendations based upon adequate mathematical preparation but inadequate language skill that may seriously limit students' success in mathematics classes. Individual institutional users of the test should be aware of the apparently different performance of Asian students on verbally loaded items; they may wish to take these differences into account when recommending placement for such students and when developing curricular programs or supplementary learning assistance for them.

Table One
MH D-DIF for Algebra Readiness on Ethnicity for Asians

	AB	AH	AW
I1	-1.15	-.43	.69
I2	-.50	-1.29	-.95
I3	-1.19	-.54	-.14
I4	-.27	-.07	.83
I5	2.08	2.39	2.12
I6	3.23	2.66	5.01
I7	-1.05	-.56	-.04
I8	1.39	1.47	2.17
I9	1.81	1.47	3.16
I10	-.31	-.15	.85
I11	-.18	-.19	-.65
I12	1.76	1.91	1.81
I13	1.74	1.49	.74
I14	.88	.34	1.35
I15	.94	.31	1.08
I16	.19	.39	1.26
I17	-.65	-.70	-1.12
I18	-.56	-.98	-.09
I19	1.51	1.20	2.62
I20	1.67	1.31	.74
I21	-1.68	-1.00	-1.61
I22	.37	.32	.32
I23	.80	.65	.43
I24	-.45	-.54	-1.30
I25	.10	.08	-.64
I26	-.94	-.35	-.20
I27	-.40	.32	-.78
I28	-2.18	-1.64	-2.06
I29	-.93	-.55	-1.04
I30	1.97	1.92	2.86
I31	-1.19	-1.41	-1.37
I32	1.51	1.51	1.26
I33	-.93	-1.42	1.78
I34	-.13	.13	-.80
I35	1.09	1.27	1.33
I36	.05	.52	-.70
I37	-.72	-.98	.77
I38	.71	1.11	.78
I39	.10	.38	.36
I40	.59	.27	-.32
I41	-.51	-.57	-1.08
I42	-.43	-.96	1.04
I43	-.95	-1.10	-.89
I44	.17	.20	1.30
I45	-.02	-.44	-.83
I46	1.57	.92	.88
I47	.67	-.01	.62
I48	.45	.04	.02
I49	.32	.24	.83
I50	.23	-.57	-.97
MEAN	.212	.167	.357
SD	1.123	1.033	1.403