The ARC Center Tri-State Student Achievement Study

A Report of the ARC Center
at
The Consortium for Mathematics and Its Applications (COMAP)

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Table of Con en s

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Figure 1: Averages for the overall test score variable "total," by state/grade and reform status.

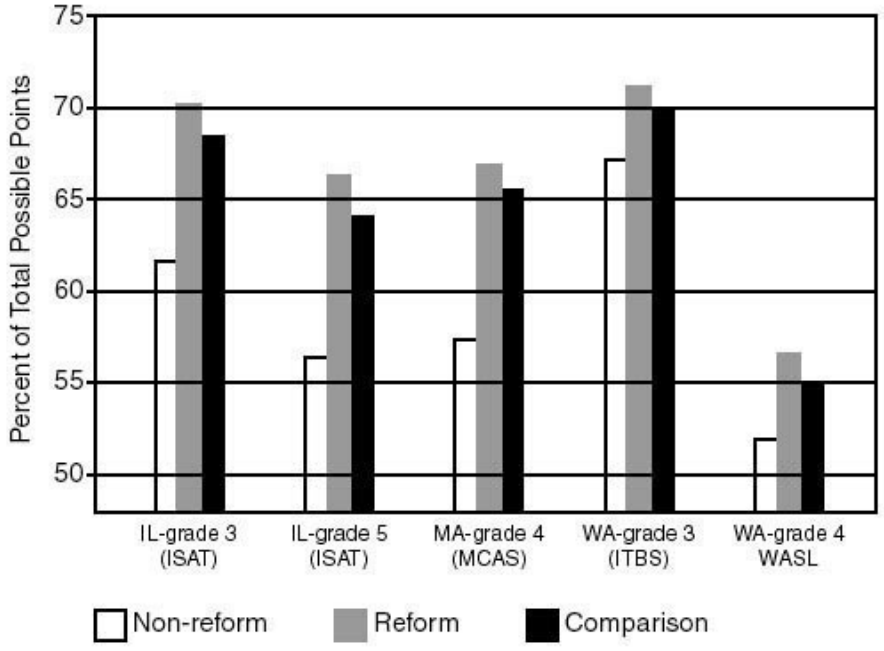


Figure 2a: Test variable averages for IL grade-3, by reform status.

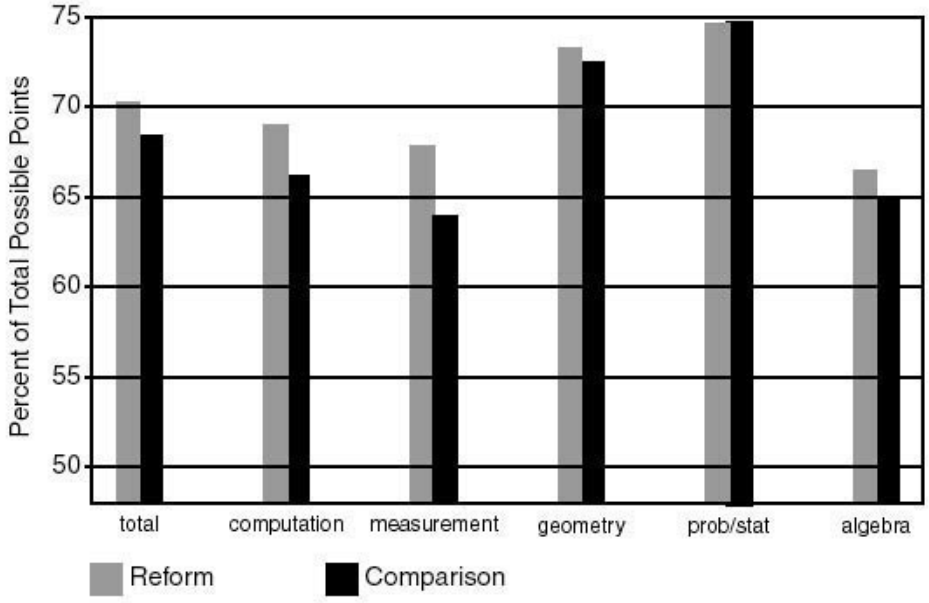


Figure 2b: Test variable averages for IL-grade 5, by reform status.

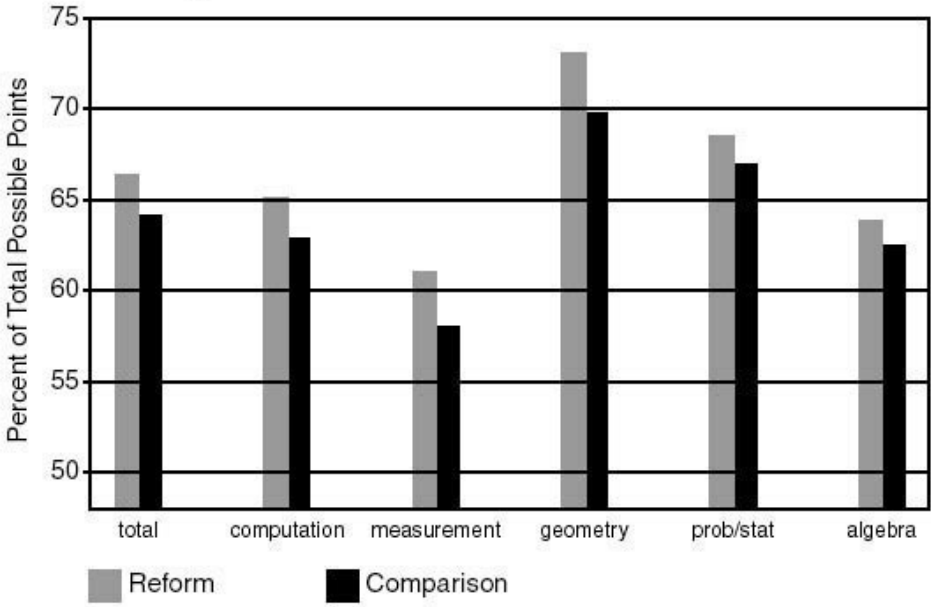


Figure 2c: Test variable averages for MA-grade 4, by reform status.

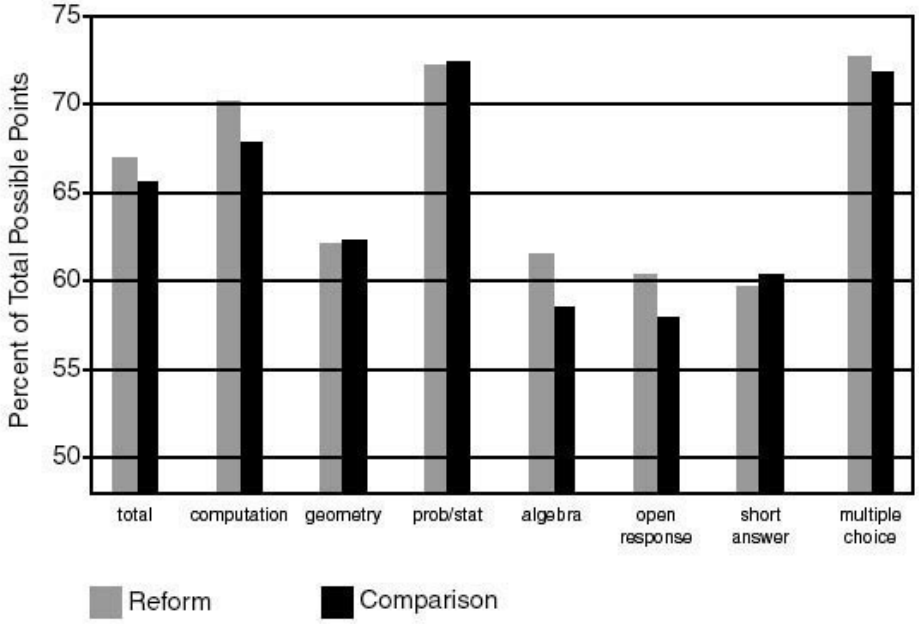


Figure 2d: Test variable averages for WA-grade 3, by reform status.

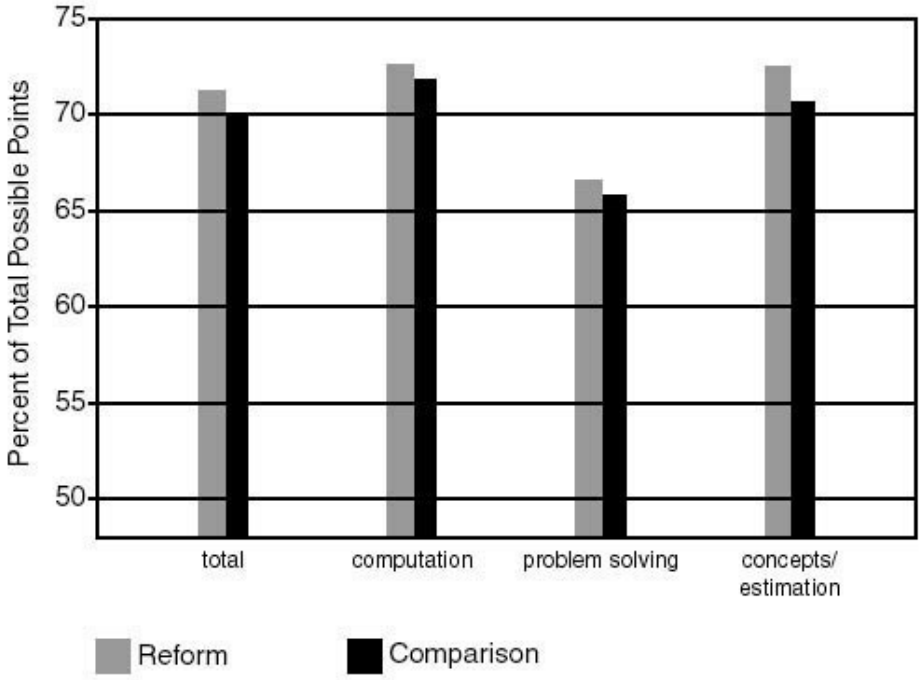
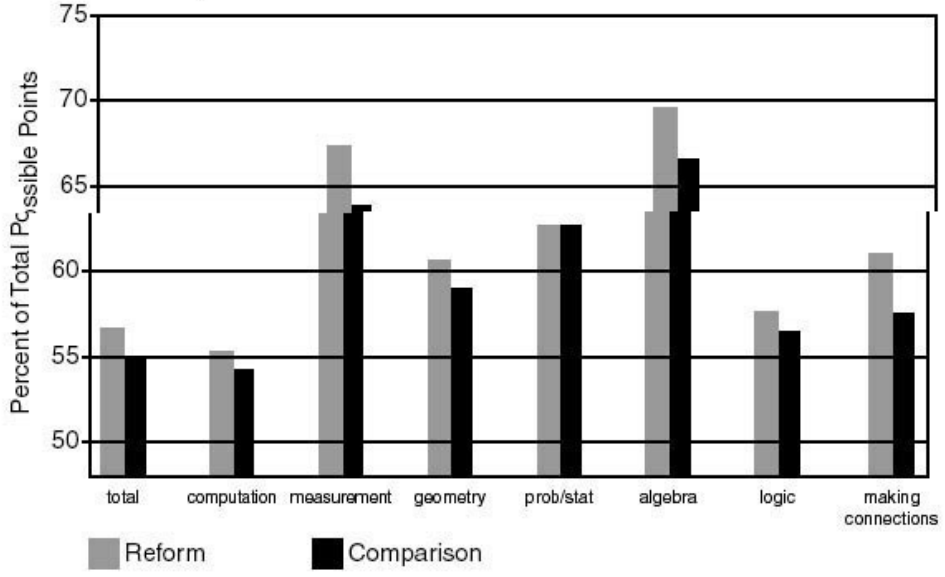


Figure 2e: Test variable averages for WA-grade 4, by reform status.



Averages for "problem solving" and "communicating" are not shown because they do not fit within the vertical scale.
For "problem-solving", the reform students' average is 38.82, and the comparison student's average is 36.31.
For "communicating", the averages are 45.03 and 45.06, respectively.

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Figure 3: Averages for the overall test score variable "total," by state/grade, race/ethnicity, and reform status.

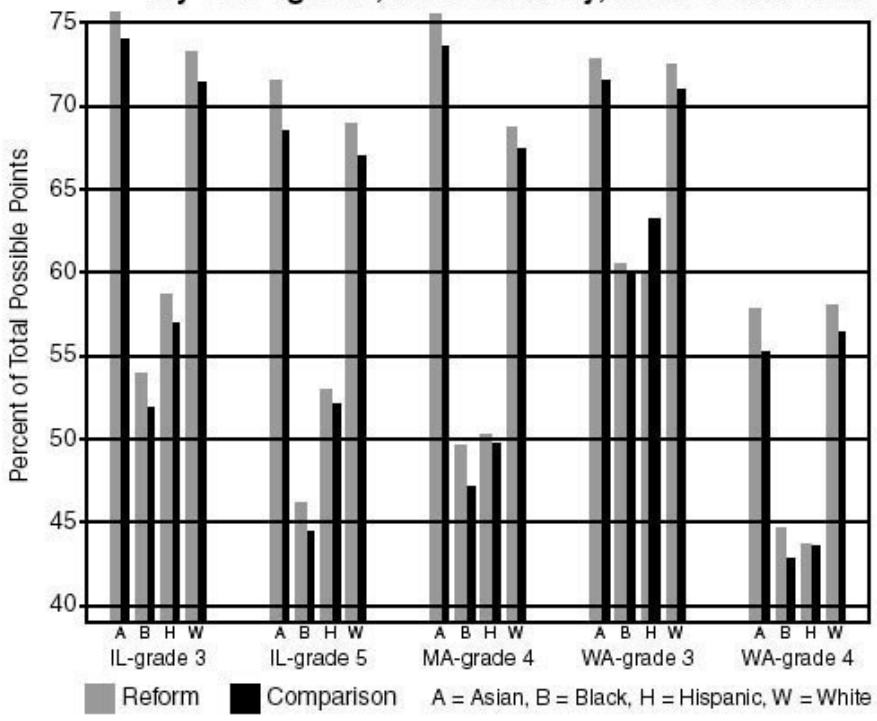

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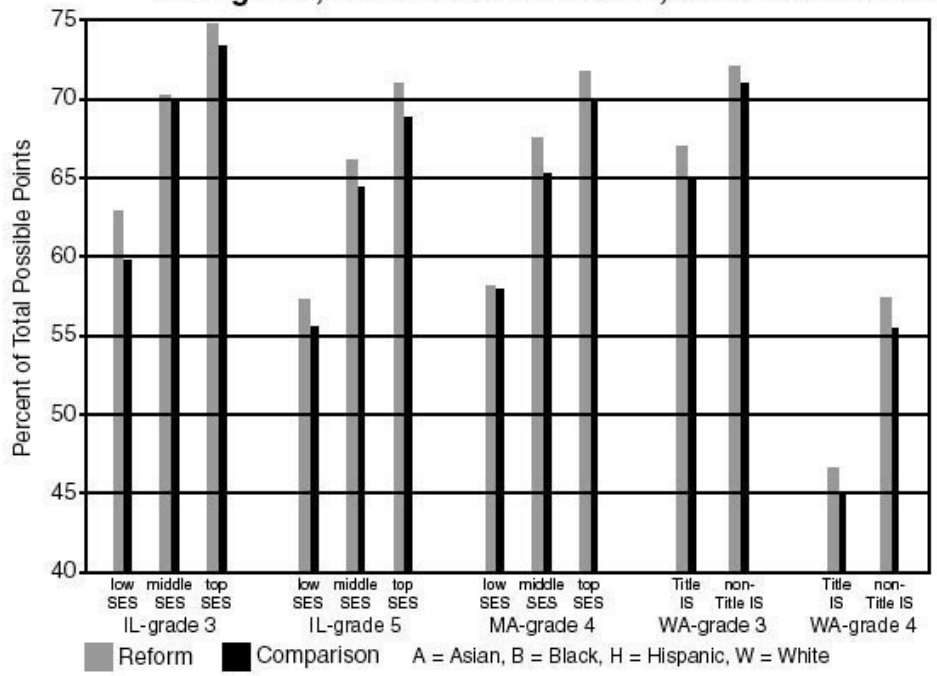
Figure 4. Averages for the overall test score variable "total," by state/grade, SES and Title IS status, and reform status.



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Appendi A

A.1 The Matching Procedure

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A.2 E clusions and Missing Data Procedures

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A.3 Construction of Case Weights for Comparison Students

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A.4 Corrective Adjustment for Matching Differences

[illegible]

[illegible]

1. [illegible]
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4. [illegible]

[illegible]

A.5 Calculation of Effect Sizes and Their Standard Errors

[illegible]

C r (R C), r r r

T r r

$r(R C) = r(R) + r(C)$

$= (1 \quad)\sigma_R^2/ R + \sigma_C^2/ C,$

r σ_R^2 σ_C^2 r , R C r ... 0.81 ... For ... 90% ... 94%, 96% ...

$= 0.90 \quad 0.94 \quad 0.96 = 0.81$

F r $\sigma_R^2 \approx \sigma_C^2$ $R \approx C$),

$r(R C) \approx 1.19\sigma_C^2/ R$

F r (R C)/ C, r C σ_C, ... 1.09/ r (R).

T ... (R CA)/ C, r CA ... A A.4. M r ... Σ (R /N) (R CA)/ C, r R ... N = Σ . I ... CA ... C ...), ... r ≈ 1.09/ r (N). F r ...

A ... T ... 25 50%. T ... F r ... < 0.01 ... < 0.001 .

A.6 Validit of Results

Reliabilit of measures and regression artifacts

T ... S 2.4 A A.1. M ... F r ... : S ... T ... M ...

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IEP (

.)

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- 10% 20%

An alternative analysis

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- (B) A A.4 .
- (C) ,

(B) 8% (A). (B) .

(C) 20% (A). (C) . 6. (.) (C) . / ,

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Appendix B

The ARC Center study includes data from five state-mandated tests administered in the spring of 2000. Table 15 compares the five tests based on the number and type of questions, time limits, and use of calculators and other tools.

Table 15: State Tests Comparison

	MA	IL	IL	WA	WA
	grade 4	**grade 3**	**grade 5**	**grade 3**	**grade 4**
Name of Test					

Information and sample items are available at www.isbe.state.il.us/assessment/isat.htm.

The *W A S L* (WASL) is designed to measure the mathematics proficiency of students according to the state *E A L R* (EALR). Administration of the test in grade 4 was voluntary in 1997 and required since 1998. A total math score is reported along with scores in the following content and process strands:

- Number Sense
- Measurement Concepts
- Geometric Sense
- Probability and Statistics
- Algebraic Sense
- Solving Problems
- Reasoning Logically
- Communicating Understanding
- Making Connections

Information and sample items are available at www.k12.wa.us

The *I w T B S* (ITBS) is a norm-referenced test. Since 1999, grade 3 students in Washington State have taken the ITBS (Form M). National norms for the test were established in 1995. The mathematics portion of the test consists of three sections:

- Math Concepts and Estimation
  The Math Concepts portion includes number properties and operations, algebra, geometry, measurement, and probability and statistics. The Estimation portion measures students' mental arithmetic and estimation skills.
- Math Problem Solving and Data Interpretation
  The Problem Solving and Data Interpretation test includes word problems and interpretation of tables and graphs.
- Math Computation
  Each problem in the Math Computation test requires the use of one arithmetic operation—addition, subtraction, multiplication, or division.

Information on the ITBS is available at www.riverpub.com/products/group/itbs and www.uiowa.edu/~itp/itbs.htm.

The *M C A S* (MCAS) was first administered in 1998. Early versions, including the spring 2000 version, were based on the 1996 *M M C F w* . The following mathematics content strands were tested:

- Number Sense
- Patterns, Relation, and Functions
- Geometry and Measurement
- Statistics and Probability

The test items from the spring 2000 administration of the MCAS are available at http://www.doe.mass.edu/mcas/2000/release/.

Sample Items

The format of the items on the tests varies widely. As shown in Table 15, all of the tests include multiple-choice items. Figure a shows two sample items from the grade3 ISAT in the Estimation/Number Sense/Computation standard set. Figure b shows a released multiple-choice item from the grade 4 MCAS from the Number Sense

reporting category and Fractions and Decimals substrand. Note that students are encouraged to use their toolkit to help solve the problem.

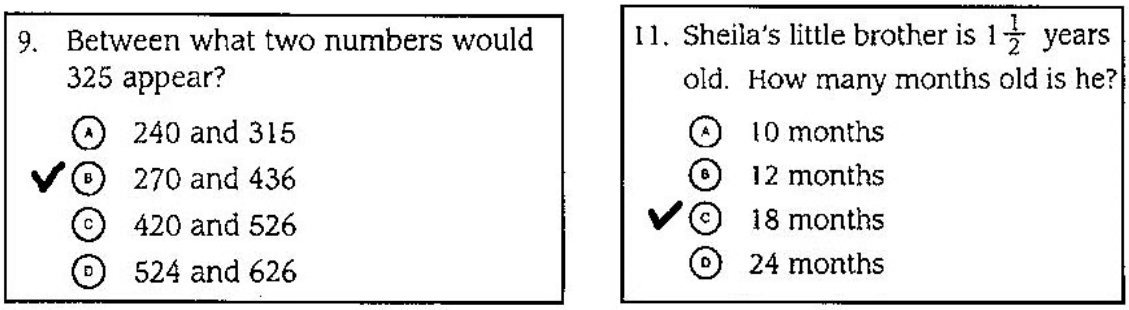

Figure a. Sample multiple-choice items from the grade 3 ISAT

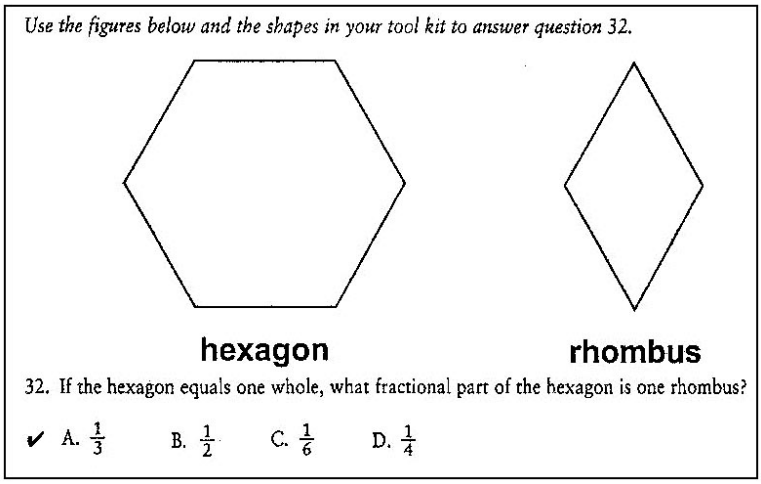

Figure b. Released multiple-choice item from the grade 4 MCAS

The state tests in Washington and Massachusetts included short-answer questions. Figure c shows two short-answer questions from the grade 4 MCAS. One is from the Number Sense reporting category and the Number Computation substrand and the other is from the Geometry and Measurement reporting category and the Measurement substrand.

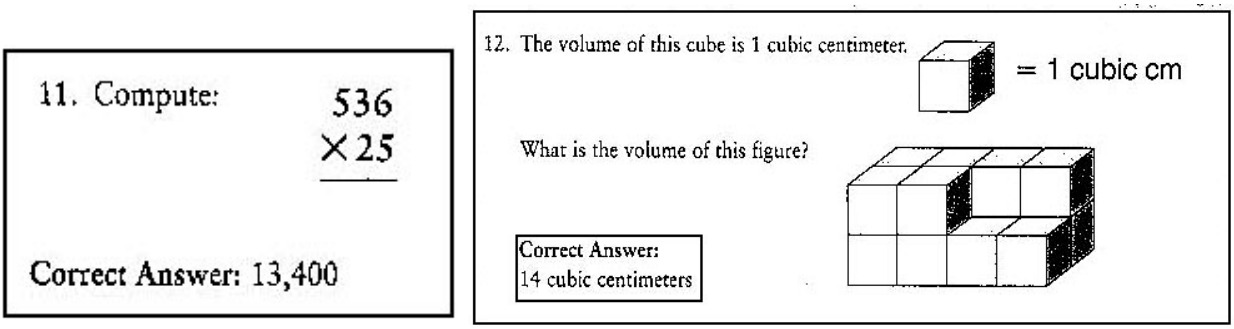

Figure c. Two short-answer questions from the grade 4 MCAS

In 2000, Washington and Massachusetts included results from open-response items in student scores. Figure d is a sample open-response item from the grade 4 WASL. Figure e is the corresponding scoring rubric.

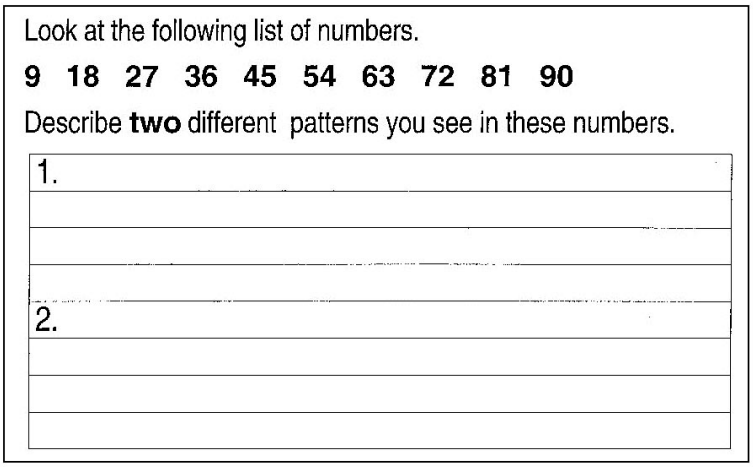

Figure d. Sample open-response item from the grade 4 WASL

2	A 2-point response describes two different number patterns in the given list of numbers. Possible patterns include the following (or equivalent statements): • All the numbers are multiples of 3. • All the numbers are multiples of 9. • The digit(s) in each number add up to 9. • The ones digit decreases by 1 in each number. • The tens digit increases by 1 in each number • You add 9 to get the next number. • Every other number is odd, or every other number is even.
1	A 1-point response does one of the following: • Describes one number pattern in the list of numbers. • Describes two different number patterns, but the descriptions may be vague, incomplete, or unclear (e.g., "the numbers are getting bigger").
0	A 0-point response shows little or no understanding of algebraic sense.

Figure e. Scoring rubric for open-response item from the grade 4 WASL

Appendix C

This Implementation Survey was administered in print and by follow-up phone interview to each school in the study using one of the reform curricula.

To:		**From:**	
		Phone:	
		Fax:	
Phone:		**e-mail**	
Fax:		**Date:**	
		Pages:	

The (name of project) at the (name of institution), with funding from the National Science Foundation and in collaboration with TERC, COMAP, The University of Chicago, and the University of Illinois at Chicago, is carrying out a study of student achievement with (name of curriculum) and two other reform-oriented curricula. As part of our study, we are surveying schools using these curricula.

The survey includes eight questions. We need this information about each school using (name of curriculum). Please look over the questions and answer them as accurately as possible. Thank you.

School: _____

Phone number and best time to call:

_____

Name and position of person completing survey:

_____

1. What was the primary mathematics program (the instructional materials) used by this school in each grade for mathematics during the 1999–2000 school year?

Grade	Primary Mathematics Program
2	
3	
4	
5	

2. What percentage of teachers for this school used (name of curriculum) or at least 75% of their math instruction during the 1999–2000 school year?

Grade	% of teachers fully using
2	
3	
4	
5	

3. As of June 2000, for this school at each grade, how many years had (name of curriculum) been fully implemented? (Use 'At least 75% of teachers using the curriculum for at least 75% of their mathematics instruction' as the definition of 'full implementation.')

Grade	Years at full?
2	
3	
4	
5	

4. As of June 2000, at each grade level, what was the total number of hours on average of staff development related to (name of curriculum) for a typical teacher using it (since 1994)?

Grade	# of hours of staff development (circle a range)			
2	0–6	7–30	31–99	100+
3	0–6	7–30	31–99	100+
4	0–6	7–30	31–99	100+
5	0–6	7–30	31–99	100+

5. How many actual minutes of mathematics instruction were there per day during the 1999–2000 school year?

Grade	Minutes per day
2	
3	
4	
5	

6. On average, for what percent of math time did teachers use (name of curriculum) during the 1999–2000 school year?

Grade	% of time
2	
3	
4	
5	

7. On average, during the 1999–2000 school year how many units (or lessons, or modules, as appropriate) did teachers complete?

Grade	# units
2	
3	
4	
5	

8. What supplementary mathematics materials (test prep, math facts practice, problem solving, etc.) were used during the 1999–2000 school year?

Grade	What supplementary materials were used?
2	
3	
4	
5	

Table 1: Number of school/grade case records coded for the implementation survey, by state and grade level

	Grade				
State	2	3	4	5	Total
Illinois	289	290*	275	254*	1,108
Massachusetts	93	159	158*	81	491
Washington	177	178*	178*	125	658
Total	559	627	611	460	2,257

* Student achievement data is available for these five state/grade combinations, which include a total of 1,058 school/grade case records.

Table 2: Number of eligible reform school/grade cases, by state, grade level, and reform program

	Reform Program			
State-Grade Level	Everyday Mathematics	Investigations	Math Trailblazers	Total
Illinois-Grade 3	203	0	13	216
Illinois-Grade 5	168	0	6	174
Massachusetts-Grade 4	64	63	0	127
Washington-Grade 3	64	15	34	113
Washington-Grade 4	63	15	34	112
Total	562	93	87	742

3: Ex h r , y r .

State	Grade level	A Total schools at grade level	B Exclusions*	C Total schools available for matching	D Number of reform schools to be matched	E Matching ratio
I	3	2,308	187	1,905	216	8.8 : 1
	5	2,184	191	1,819	174	10.5 : 1
h	4	1,051	173	751	127	5.9 : 1
h	3	1,150	248	789	113	7.0 : 1
	4	1,149	254	783	112	7.0 : 1
		7,842	1,053	6,047	742	

* I r x , h / r h r r y , h r h r y h / r h r r 737 r x h / r h r r y , r r 9.4% fh h / r A

h A h fh , , .

h h r E h r fh .

4: h r r f r r f r h / r h r r h / r *.

State-Grade Level	Matching Variable			
		Average percentage of:		
I - r 3 r r	h	-	y	EP
f r	165.75	74%	18%	13%	6%
r	165.85	77%	18%	13%	5%
I - r 5 r r	h	-	y	EP
f r	164.46	76%	17%	11%	5%
r	164.2	81%	18%	12%	4%
h - r 4 r r	h	f r / r h	y **	EP**
f r	236.99	77%	12%	16%	2%
r	236.28	80%	14%	11%	1%
h - r 3 r r	h	I h	I	
f r	192.07	80%	2%	16%	
r	191.97	82%	2%	16%	
h - r 4 r r	h	I h	1	
f r	412.46	80%	3%	6%	
r	412.36	82%	3%	6%	

* A r f r r h h r h r . (A x A, 3.)

** r r k h .

Table 5: Student record counts at various stages of exclusion, by state and grade level

State	Grade Level	A reform and comparison school records on state file prior to exclusions	B records after excluding math-disabled/IEP/special education students	C records after excluding students with incomplete math test data	D missing data reading score	D missing data race/ ethnicity	E* records in final file used for tabulations and constructing case weights
Illinois	3rd	32,923 8.7% are IEP	30,052	29,490	498	1,249	28,992 14,875 reform 14,117 comparison
	5th	30,807 9.9% are IEP	27,763	27,555	74	1,195	27,481 13,820 reform 13,661 comparison
Massachusetts	4th	17,822 15.8% are math-disabled	15,010	14,575	84	94	14,397 6,879 reform 7,518 comparison
Washington	3rd	16,868 9.1% are spec-edn/IEP	15,333	14,794	125	458	14,669 7,813 reform 6,856 comparison
	4th	17,702 11.1% are spec-edn	15,737	15,407	71	274	15,336 7,953 reform 7,383 comparison
Total		116,122	103,895	101,821	852	3,270	100,875 51,340 reform 49,535 comparison

* Excepting Massachusetts, the total count in Column E is equal to the count in Column C minus the count for reading score in Column D.
For Massachusetts, the total count in Column E is equal to the count in Column C minus the sum of the counts in Column D.

Table 6: Number of student records used for tabulated comparisons, by state, grade level, school status, and curriculum.

			R P			
S	G L	S S	E M	I	T	T
Illinois	3rd	Reform	13,840	0	1,035	14,875
		Comparison	13,216	0	901	14,117
	5th	Reform	12,988	0	832	13,820
		Comparison	13,098	0	563	13,661
Massachusetts	4th	Reform	3,962	2,917	0	6,879
		Comparison	4,181	3,337	0	7,518
Washington	3rd	Reform	4,412	916	2,485	7,813
		Comparison	3,923	783	2,150	6,856
	4th	Reform	4,499	920	2,534	7,953
		Comparison	4,063	907	2,413	7,383
T		Reform	39,701	4,753	6,886	51,340
		Comparison	38,481	5,027	6,027	49,535
			78,182	9,780	12,913	100,875

Table 7: Average differences and effect si es, b state/grade combination.

		math	total	computation	measurement	geometr	prob/stat	algebra				
IL grade3	difference	1.39***	1.82***	2.78***	3.84***	0.76***	0.06	1.44***				
(n=14,875)	effect si e	0.098	0.099	0.141	0.164	0.038	0.003	0.073				
IL grade5	difference	1.82***	2.20***	2.29***	3.02***	3.26***	1.55***	1.44***				
(n=13,820)	effect si e	0.121	0.116	0.117	0.132	0.165	0.079	0.067				
									open response	short answer	multiple choice	
MA grade 4	difference	1.34***	1.33***	2.36***		-0.19	-0.16	3.07***	2.46***	-0.62	0.89***	
(n=6,879)	effect si e	0.087	0.078	0.127		-0.010	-0.008	0.137	0.119	-0.024	0.053	
									problem solving	concepts/ estimation		
WA grade3	difference	1.34***	1.27***	0.74**					0.76**	1.86***		
(n=7,813)	effect si e	0.073	0.078	0.039					0.036	0.108		
										logic	commun- icating	making connections
WA grade4	difference	3.02***	1.77***	1.02***	3.43***	1.61***	0.00	2.99***	2.51***	1.17***	-0.03	3.55***
(n=7,953)	effect si e	0.093	0.093	0.041	0.120	0.078	0.000	0.112	0.090	0.040	-0.001	0.116
Combined	effect si e	0.098***	0.097***	0.102***	0.142***	0.078***	0.025***	0.088***				
(n=51,340)	percentile change	+3.92%	+3.88%	+4.08%	+5.68%	+3.12%	+1.00%	+3.52%				

"Math" is scaled test score; "total" and remaining strand scores are percent of total possible points on entire test or appropriate strand portion of test.

The record counts in column one are the numbers of reform-student records used for tabulations. For an given tabulation, the weighted number of comparison-student records used is equal to the number of reform-student records used.

Two-sided significance levels are defined as follows: *** is $p < 0.001$, ** is $p < 0.01$, * is $p < 0.025$.

Table 8: A erage effec -i e- and percen ile change-, b - den race/e hnici

		ma h	o al	comp a ion	mea- remen	geome r	prob/- a	algebra
A-ian	effec -i e	0.106***	0.115***	0.097***	0.175***	0.162***	0.043	0.086***
(n=3,071)	percen ile change	+4.24%	+4.60%	+3.88%	+7.00%	+6.48%	+1.72%	+3.44%
Black	effec -i e	0.092***	0.101***	0.109***	0.129***	0.081***	0.029	0.087***
(n=3,509)	percen ile change	+3.68%	+4.04%	+4.36%	+5.16%	+3.24%	+1.16%	+3.48%
Hi-panic	effec -i e	0.021	0.031	0.017	0.094***	0.049*	-0.005	0.035
(n=3,002)	percen ile change	+0.84%	+1.24%	+0.68%	+3.76%	+1.96%	-0.20%	+1.40%
Whi e	effec -i e	0.100***	0.100***	0.106***	0.144***	0.070***	0.020***	0.091***
(n=37,609)	percen ile change	+4.00%	+4.00%	+4.24%	+5.76%	+2.80%	+0.80%	+3.64%
Combined	effec -i e	0.098***	0.097***	0.102***	0.142***	0.078***	0.025***	0.088***
(n=51,340)	percen ile change	+3.92%	+3.88%	+4.08%	+5.68%	+3.12%	+1.00%	+3.52%

"Ma h" i- -caled e- -core; " o al" and remaining - rand -core- are percen of o al po--ible poin- on en ire e- or appropria e - and por ion of e-

compari-on- den
record- -ed i- ro ghl eq al o he n mber of reform- den record- -ed.
- be-eq en l imp ed.
The ab la ion- for geome r , prob/- a and algebra are ba-ed on 5-10% fe er - den record-, beca -e he-e - rand- are no -epara el -cored in he WA (grade 3) e- .
he WA (grade 3) e- .

T o-ided -ignificance le el- are defined a- follo -: *** i- p < 0.001, ** i- p < 0.01, * i- p < 0.025

	(< , 23)		0.114*** +4.5 %	0.102*** +4.0 %	0.103*** +4.12%	0.144*** +5. %	0.152*** + .0 %	0.02 * +1.0 %	0.0 2*** +2. %
	(< ,4)		0.0 *** +3.0 %	0.0 *** +3.12%	0.124*** +4. %	0.110*** +4.40%	0.000 +0.00%	0.004 +0.1 %	0.0 1*** +3.24%
	(< 1 ,3 5)		0.101*** +4.04%	0.10 *** +4.32%	0.151*** + .04%	0.150*** + .00%	0.04 *** +1. 4%	0.03 *** +1.5 %	0.0 1*** +3.24%
	(< 1, 3)		0.0 *** +3. 4%	0.0 4*** +3. %	0.04 +1. 4%	0.0 5 # +2. 0%	0.032 # +1.2 %	-0.02 # -1.04%	0.0 # +3.4 %
	(< 13, 3)		0.0 3*** +3.32%	0.0 5*** +3.40%	0.03 *** +1.5 %	0.125*** +5.00%	0.0 2*** +3.2 %	0.003 +0.12%	0.11 *** +4. 4%
	(< 51,340)		0.0 *** +3. 2%	0.0 *** +3. %	0.102*** +4.0 %	0.142*** +5. %	0.0 *** +3.12%	0.025*** +1.00%	0.0 *** +3.52%

20%

50

4

4

50

,44

***, 0.001, **, 0.01, *, 0.025

		0.09 *** +3. %	0.09 *** +3. %	0.105*** +4.20%	0.144*** +5. %	0.0 1*** +3.24%	0.023*** +0.92%	0.0 *** +3.5 %
M (24,933)		0.09 *** +3. 4%	0.094*** +3. %	0.09 *** +3.92%	0.140*** +5. 0%	0.0 4*** +2.9 %	0.024*** +0.9 %	0.0 4*** +3.3 %
(51,340)		0.09 *** +3.92%	0.09 *** +3. %	0.102*** +4.0 %	0.142*** +5. %	0.0 *** +3.12%	0.025*** +1.00%	0.0 *** +3.52%

15% = (1, 3)

30% M= (1, 4) = (1, 3)

*** 0.001, ** 0.01, * 0.025

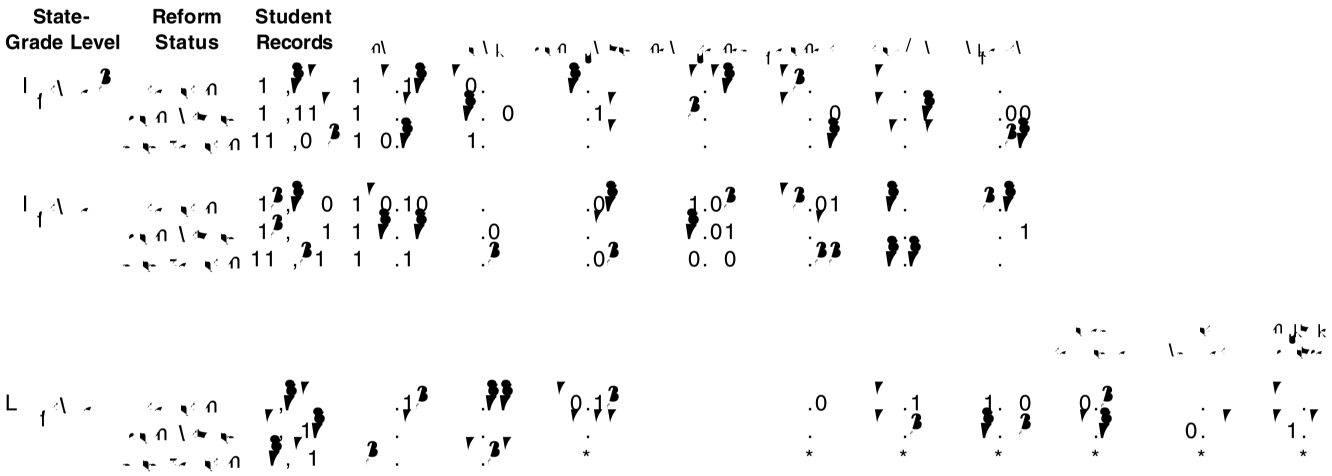
State-
Grade Level
Reform
Status
Student
Records

Table 12: [illegible] *

Variable	Grade 3 (ISAT)	Grade 5 (ISAT)	Grade 4 (MCAS)	Grade 3 (ITBS)	Grade 4 (WASL)
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible] ([illegible])	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
LEP ([illegible])	[illegible]	[illegible]	[illegible]		
[illegible] ([illegible])	[illegible]	[illegible]	[illegible]		
[illegible]	[illegible]	[illegible]	[illegible]		
T[illegible]				[illegible]	[illegible]
SES ([illegible] [MA])	[illegible]	[illegible]	[illegible]		

* [illegible]

F[illegible] (MA) LEP (MA) [illegible]

Table 13. Estimated bias due to regression artifacts.
(Typical results based on IL-grade 5 data.)

		Assumed covariate reliabilities: read=0.99, lowincom=0.98, white=0.98	Assumed covariate reliabilities: read=0.97, lowincom=0.92, white=0.92
Test variable modeled	**Covariates used**	**Estimated bias**	**Estimated bias**
math	reading score	+4.2%	+8.2%
math	low-income %	+1.2%	+21.9%
math	reading score low-income %	+4.1%	+5.6%
math*	reading score low-income % white %	+6.2%	+3.0%
computation	reading score low-income %	+2.1%	+3.8%
algebra	reading score low-income %	+6.3%	+13.4%
algebra	reading score low-income % white %	-3.2%	+15.4%

* Math was also modeled using these same covariates, but with unrealistically low assumed reliabilities: read=0.90, lowincom=0.90, and white=0.90. The estimated bias was +38.3%.

math	total	computation	measurement	geometry