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ABSTRACT

This report is the beginning of a series that will examine the performance of the school children of New Jersey relative to the performance of other children in the United States and worldwide. The measure of performance used was the 1992 National Assessment of Educational Progress (NAEP) mathematics examinations and their linked versions of the 1991 International Assessment. The NAEP is used because it is satisfactory in content and form and because the psychometric model underlying its scoring yields a single scale that allows easy comparison. Students sampled by the NAEP are drawn in a principled way from the populations of interest, supporting the accuracy and honesty of the assessment. Based on unstandardized results of the 1992 mathematics assessment, New Jersey was among the highest performing states. When results were standardized to reflect a single national demographic composition, New Jersey's rank among participating states rose to fourth. The United States, however, finished next-to-last when compared with the other 14 nations. The top 5% of New Jersey students ranked third when compared with the top 5% of members of the Organization for Economic Cooperation and Development. Seven figures illustrate the discussion. (Contains 10 references.) (SLD)

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Introduction

"...teaching is validated by the transformation of the minds and persons of the intended audience."

Bressler, 1991

The most critical measure of any educational system is the performance of its students. But what yardstick should be used to accomplish this measure? The fact that modern education has many goals suggests that we must measure the extent of its success in a variety of ways. This report describes the first of a series of researches that will attempt to characterize the performance of New Jersey's public school system. We will do this through comparative and absolute measures, the primary instrument of which will be the data gathered during the course of the National Assessment of Educational Progress (NAEP).

NAEP is a congressionally mandated survey of the educational achievement of American students and of changes in that achievement across time. Although this survey has been operational for nearly 25 years, it was only in 1988 that Congress authorized adding state level surveys to the national assessment. This was begun on a trial basis with states participating on a voluntary basis. In 1990 37 states, two territories and the District of Columbia participated in the first Eighth Grade Math Assessment. In 1992 seven more states joined the state assessment yielding 44 jurisdictions. The 1992 assessment was expanded to also include the Fourth grade. In this report we shall focus attention only upon the 41 states in the assessment. Guam, the Virgin Islands and the District of Columbia will be explicitly excluded because they are sufficiently different from the states in their size, character and composition so as to distort most comparisons.

The assessment methodology is technically sophisticated. Through the use of linking items and item response theory, the performance of all students participating in the assessment can be placed on the same numerical scale. Measuring students' growth is thus straightforward. Subtracting 4th grade scores from 8th grade scores is the growth obtained. Consequently the expansion of the assessment to the fourth grade provides us with two important bits of information. First, is a measure of how much mathematics Fourth graders know. Second, a measure of how much mathematics is learned between 4th and 8th grade. Note that having a measure of the gain obtained (about 49 NAEP points on average) helps us to interpret the NAEP scale. It tells us that if one state trails another by about 12 points this is about the same as the average gain in one year of

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school. Thus, when we compare California's mean 8th grade NAEP score of 261 to New Jersey's score of 273, we can interpret the 12 point difference as indicating that the average California 8th grader performs about the same in mathematics as the average New Jersey 7th grader would have. This helps give additional meaning to the numerical scale.

More meaning still for the eighth grade math assessment is yielded by comparing performance on it with performance of 13 year old students in the 1991 International Assessment. Because the NAEP Math assessment was coordinated with the International Assessment both sets of scores can, with reasonable confidence, be placed on the same scale. This was accomplished by having a common sample of examinees for both assessments. As we shall see, the performance of New Jersey's students compares favorably with those from the developed nations.

The Mathematics assessment contained tasks for the students drawn from the framework provided by the *Curriculum and Evaluation Standards for School Mathematics*, developed by the National Council of Teachers of Mathematics. The content and the structure of the assessment has been widely praised as being representative of the best that current knowledge and technology allows. A full description of the 1992 Mathematics Assessment is found in *NAEP 1992: Mathematics Report Card for the Nation and the States* (Mullis, Dossey, Owen, & Phillips; 1993).

The NAEP State Assessment Sample

Within each state 100 public schools are carefully selected to be representative of all public schools in that state. Within each school at least 30 students are chosen at random to be tested (in larger schools this number can be as large as 90). Students (usually of foreign birth) whose English language proficiency is deemed to be insufficient to deal with the test, are excluded from the sampling frame.

The Results

All results are reported on a uniform scale that can meaningfully characterize the performance of students over a very wide range of proficiency. This scale can be used in a normative manner, for example comparing one state with another, or one state with the nation as a whole. Or it can be used as an absolute measure, since expert judges have provided a correspondence between score levels and specific proficiencies. These proficiencies are denoted Basic, Proficient and Advanced and what is required to perform at each of these levels obviously increases as the student progresses through school, but are always referred back to the five NAEP content areas. These are: (1) numbers and operations, (2) measurement, (3) geometry, (4) data analysis, statistics, and probability, and (5) algebra and functions.

For example, a score of 211 is characterized as "Basic Level" fourth grade performance. "Basic Level" is defined as *"showing some evidence of understanding the mathematical concepts and procedures of the five NAEP content areas."* The second level is called "Proficient" and is located at score 248 and reflects being able to *"consistently apply integrated procedural knowledge and conceptual understanding to problem solving in the five NAEP areas.* " The highest performance level is termed "Advanced", is located at score 280 and reflects the ability to "*apply integrated procedural knowledge and conceptual understanding to complex and nonroutine real-world problem solving in the five NAEP areas.*"

The mean performance of all participating states for the 8th grade assessment is shown in Figure 1.

Insert Figure 1 Here.

The results shown in Figure 1, while accurately reflecting the actual mean performance within each state, may not be appropriate for certain kinds of state-by-state comparisons. The student populations of each state differ in their demographic make-up. As such, some states face more difficult challenges in educating their populations than others. One obvious example of such a situation occurs in states like California, New Jersey and Florida that have large immigrant populations whose children, even if they do not participate directly in the assessment, require a larger share of instructional resources than native English speakers. In addition, the various subpopulations of students in each state often perform very differently from one another. For example, in Figure 2 are displayed the mean performance of students in different parts of the country broken down by race/ethnicity.

Figure 2 has two important messages:

1. There are very large differences in performance by ethnic group. These differences are much larger than the geographic variation observed.

2. New Jersey's students perform better than the national average and all regional averages for all groups. Thus although it is true that New Jersey's African-American and Hispanic students do worse than White students, they do better than African-American and Hispanic students in any region.

Insert Figure 2 Here

In addition to the widely different performances of the various demographic subgroups, the distribution of these groups is not uniform across all states. A brief summary of these distributions is shown in Table 1. As is evident, New Jersey's racial/ethnic distribution is rather close to that of the nation as a whole. The central states are the most deviant in the sense that they have a substantially larger proportion of their student population that is White.

NAEP 1992 Trial State Assessment

Percentage Race/Ethnic Representation in NJ
Compared to that in other parts of the Nation

Mathematics	*White*	Race/Ethnicity *Black*	*Hispanic*	*Asian*	*Other*
NATION	**69**	**17**	**10**	**2**	**2**
Northeast	68	20	9	2	1
Southeast	63	29	5	1	2
Central	79	11	7	1	2
West	65	11	16	5	3
NJ	**67**	**14**	**13**	**5**	**1**

Table 1. The national and regional racial/ethnic distribution.

If we wish to use such data to draw inferences about the relative efficacy of a state's schools, it is considered good practice to statistically adjust for the demographic differences. Why is it helpful to make such adjustments? It is beyond the goals of this report to investigate fully why there are differences in performance by demographic group, although there is a rich literature of fact and conjecture that attempts to do so[1]. However, to understand why we need to make a statistical adjustment it is important to provide some explanation. To do so requires that we draw the important distinction between education and schooling. The school is only one agency among many -- family, church, neighborhood, mass media -- that provides children with windows on the world. Mass schooling was invented because families could no longer perform essential educational functions. "Once upon a time schools could proceed on the only partly fictitious assumption that, in their efforts to teach children, they were supported by relatively stable families, and by neighborhoods that enforced elementary standards of civility." [2] Not only is this is much less true now than in the past, but also it is less true within some demographic groups than others. NAEP measures education and not just schooling, but inferences about the differences among states are explicitly about schools. To add some validity to those inferences we must try, statistically, to place all states on a

[1]The Coleman report (Coleman et al, 1966) remains the most encyclopedic of such investigations, summarizing, as it does, the performance of more than 645,000 children in 4,000 public schools. It arrives at the not surprising conclusion that family and economic variables drive educational achievement.
[2]This quote and much of the surrounding logic comes from Marvin Bressler's delightful and wise 1992 essay, "A teacher reflects."

level playing field with respect to their children's nonschool educational opportunities. Adjusting for differences in demographic groupings is a crude beginning.

What follows is a methodology that recognizes that such differences exist, and a statistical technology that attempts to partition state differences due to demographics from those due to differences in school performance.

Interpretable comparisons through statistical standardization

The between-state comparisons that are implicit in Figure 1 can yield misleading inferences if one is not acutely aware of the differences in the demographic make-up of all of the constituent units. This is of such a complex nature that it is impossible to keep things straight without some formal adjustment. One accepted way to accomplish this adjustment is termed 'standardization' (Mosteller & Tukey, 1977, p. 223). The basic idea of standardization is to choose some specific demographic proportions as the standard and then estimate each state's mean proficiency on that specific mixture. In this instance it is sensible to choose the configuration of the entire United States as the standard mixture. Thus the estimated score for each state will be the answer to the question, "What would the national average be if all children went to school in this state?"

How is this adjustment accomplished? It is very simple in theory, although sometimes, because of peculiarities in sampling weights, a bit tricky to execute. We take the mean score obtained in a state for a particular subgroup and multiply it by that subgroup's proportional representation in the standard (national) mixture. Do this for all subgroups and the resulting score is the adjusted one. So far we have reported New Jersey's scores for four racial/ethnic groups. As we have seen, because New Jersey's demographics are so much like the national standard this sort of adjustment would have little effect. A greater effect would be on more disparate areas (i.e. the central US,). Is it sufficient to adjust simply on the basis of this one demographic variable? No, although if we adjust on too many variables, and so include some irrelevant ones, no damage will be done, since irrelevant variables will typically not show differences in performance. In this paper we adjust on three variables. These are:

1. Race/ethnicity - Five categories: White, African-American, Hispanic, Asian/Pacific Islander, Other

2. Type of community - Four categories: Extreme Rural, Advantaged Urban, Disadvantaged Urban, Other.

3. Limited English Proficiency - Two categories: Yes, No

This resulted in dividing each state up into forty pieces corresponding to the forty possible combinations (5×4×2) and calculating the mean proficiency within each of those 40 groups. These 40 means were then weighted by their representation in the entire nation yielding a standardized score for each state. The results of this standardization are shown in Figure 3.

Insert Figure 3 Here

After standardization to national demographic norms we find that although New Jersey's mean score has not changed much, ten other states, with more homogeneous student populations (e.g., Massachusetts, Wisconsin, Iowa, Idaho, North Dakota) that had previously been slightly higher are now ranked equal to or below New Jersey.

What is the point of standardization? There are many reasons. So far we have mentioned just one -- making comparisons between states on the basis of their children's performance on the same tasks and not on the differences in the demographic structure of their population. A second, and oftentimes more important use of standardized scores is in easing the difficulties in making inferences about changes that occur within a state across time. When changes do occur the standardized scores assure that the change reflects changes in the students' performance and not changes in the demographic structure of the state. We expect that as time goes on this will be the aspect of greatest value of the standardization.[3]

A natural question to ask is, "At what age do the differences observed among the states manifest themselves?" If we see the same difference between two states in 4th grade as we do in 8th, it implies that the lower scoring state needs to place more emphasis on learning in lower grades. If the difference observed in 4th grade grows proportionally larger in 8th it means that the deficit is spread throughout the years of school and a more systemic change is needed for improvement. Trying to make inferences of this sort based on just two time points is risky, but is certainly instructive. Shown in Figure 4 are the standardized scores for the 1992 4th grade math assessment. A comparison with the 8th grade rankings shown in Figure 3 indicates that the positions established in 4th grade are maintained and the differences observed between states increase. The range of 24 NAEP points observed between the relatively extreme states of North Dakota and Mississippi in 8th grade was 13 NAEP points in 4th grade. One way to interpret this is that the average Mississippi 4th grader was a year behind the average North Dakota 4th grader in math, and by the time they both reached 8th grade this deficit had increased to two years.

Insert Figure 4 Here

[3] A caveat: Big changes as a result of a statistical adjustment tell us that great care must be exercised in making inferences. A careful comparison of Figure 1 and Figure 3 reveals that most states do not change very much. This is evidence that the standardization is generally behaving as it ought, for if one disagrees with the structure of the adjustment one can still be content that it isn't changing anything drastically. A notable exception to this would be the District of Columbia, whose small size and atypical demographic structure would combine to yield an enormous shift. Inferences about the meaning of its standardized location ought not be the same as those drawn about the states. For the more important purpose of tracking changes in a jurisdiction's performance over time, it is probably prudent to develop a special standardization for each of the four most unusual jurisdictions (DC, Hawaii, Guam, Virgin Islands).

By subtracting the scores shown in Figure 4 from those in Figure 3 we obtain estimates of the average growth exhibited in each state. This result is shown in Figure 5 below. All states' scores are standardized to the demographic structure of the nation as a whole. Thus were these results longitudinal rather than cross-sectional, we would be able to interpret the changes as due entirely to growth and not demographic changes. As they are now constituted these changes in scores are due to differences in performance and not to demographic differences in the two grades.

Insert Figure 5 Here

International Comparisons

As mentioned previously, the 1991 International Assessment contained enough NAEP items to allow accurate comparisons. The most newsworthy result was that the United States finished near the bottom in this assessment, finishing ahead of Jordan but behind all of the participating developed nations. This was (properly) viewed with alarm. But, as we have seen in the preceding figures, there is tremendous variation within the United States. Shown in Figure 6, are the results of this assessment augmented by the inclusion of New Jersey (standardized to national demographics). As is evident, New Jersey's students' performance was sixth among all nations participating in the assessment. Further details of the International Assessment can be found in Salganik, Phelps, Bianchi, Nohara, & Smith (1993).

Insert Figure 6 Here

Interpretation of this figure is helped by remembering that, on average, students advance roughly 12 NAEP points a year. Thus the average student in Taiwan and Korea is about a year ahead of the average New Jersey student, who is within a month or two of the other developed nations.

Thus we see rather dramatically that because of the great diversity within the United States looking at just an overall figure for the entire country provides an incomplete and, for some purposes, misleading picture. Because New Jersey's score is standardized to the demographic structure of the entire nation one can interpret this result as what the nation's location would have been if all of the states' educational systems performed as well as New Jersey's.

Within state variation

We have seen that the variation among states (roughly 30 NAEP points from highest to lowest) makes interpretation of a national mean of limited value. In the same way, the variation within states dwarfs the variation between them. In most states the average score obtained by the lowest 10% of the students is more than 90 NAEP points lower than the score obtained by the top 10%[4]. 90 points is an enormous gulf. Before trying to understand the reasons for this great disparity (with an eye toward developing strategies for ameliorating it) it will be useful to continue this series of comparisons for one important segment of the population -- the very top.

In Figure 7 is a comparison of the performance of the top 5% in the 1992 8th grade math assessment with the top 5% of the various OECD countries. We see immediately that New Jersey's top 8th grade students compare favorably with their counterparts throughout the world. The United States as a whole has also improved relative to the other countries, but still lags the other developed nations by from 3 to 12 months.

Insert Figure 7 Here

Summary & Conclusions

This report is the beginning of a series that examines of the performance of New Jersey's school children relative to other children within the United States and worldwide. The measure of performance used was the 1992 National Assessment of Educational Progress mathematics exams and their linked versions used in the 1991 International Assessment. This is done in the ardent belief that the efficacy of schools must be measured by the performance of their students. We chose NAEP for several reasons, three of which were:

1. It is composed of test items that satisfy the best of current wisdom with respect to both their content and their form.

2. The psychometric model underlying the scoring of NAEP yields a single scale on which not only can the fourth grade and eighth graders be characterized, but also the 13 year olds from the OECD countries from around the world.

3. The students sampled by the NAEP are drawn in a principled way from the populations of interest. This in sharp contrast to the sorts of self-selected samples that are represented by state means of such college admission tests as the SAT and the ACT. It is well known that trying to draw inferences of

[4] In all but one of the OECD countries this gulf between the 10th percentile and the 90th is somewhat smaller, about 70 points. Taiwan is the lone exception a difference of 96 points.

useful accuracy from such self-selected samples is impossible (Wainer, 1986a, b; 1989a, b).

We concur with prevailing expert opinion that of all broad-based tests NAEP provides the most honest and accurate estimates of the performance of the students over the broad range of jurisdictions sampled.

We found that, based on the unstandardized results of the 1992 Mathematics Assessment, New Jersey was among the highest performing states. Once these results were standardized to reflect a single (national) demographic composition New Jersey's rank among the participating states increased to fourth.

The United States finished next to last when the performance of it's students was compared with that of the students in the other 14 participating OECD nations in the 1991 International Assessment. New Jersey's students were ranked sixth on the same assessment when their performance was placed on the same scale. However New Jersey's best students, it's top 5%, when compared with the performance of the top 5% of all other OECD nations, ranked third; trailing only Taiwan and Korea.

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NAEP 1992 Mathematics Assessment

Overall Proficiency-8th Grade Mathematics (unstandardized)

283	Iowa	North Dakota		
282	Minnesota			
281				
280				
279				
278	Maine	New Hampshire		
277	Nebraska	Wisconsin		
276				
275				
274	Idaho	Wyoming	Utah	
273	Connecticut			
272	Colorado	Massachusetts		
271	**New Jersey**	Pennsylvania		
270	Missouri			
269	Indiana			
268				
267	Michigan	Oklahoma	Virginia	Ohio
266	**NATION**	New York		
265	Arizona	Rhode Island		
264	Maryland	Texas		
263				
262	Delaware			
261	Kentucky			
260	California	South Carolina		
259	Florida	New Mexico	Georgia	
258	West Virginia	Tennessee	North Carolina	
257	Hawaii			
256				
255	Arkansas			
254				
253				
252				
251	Alabama			
250				
249	Louisiana			
248				
247				
246	Mississippi			

Figure 1. A stem & leaf display of the 1992 NAEP State Assessment in 8th Grade Mathematics. These results are the raw (unstandardized) means from each state. New Jersey ranks 14th among all participants.

NAEP 1992 Trial state Assessment

Subgroup comparisons of NJ with other parts of the Nation

Grade 8 Mathematics	Race/Ethnicity: *White*	*Asian/Pacific Islander*	*Hispanic*	*African-American*
297		NJ		
296				
295				
294				
293				
292				
291				
290				
289				
288				
287		**NATION**		
286		West		
285				
284				
283	**NJ**			
282				
281				
280	Central			
279	Northeast			
278				
277	West			
276	**NATION**			
275				
274				
273				
272				
271				
270				
269	Southeast			
•	•	•	•	•
•	•	•	•	•
•	•	•	•	•
248				
247			**NJ**	
246			Central	
245			**NATION**	
244				
243			West	
242				**NJ**
241			Northeast	
240			Southeast	
239				Northeast, Central
238				
237				
236				**NATION**
235				
234				West
233				Southeast

Figure 2. A stem & leaf depiction comparing the performance New Jersey's students, broken down by race/ethnicity, with similar groups from all other parts of the country. Samples of "Asian/Pacific Islanders" were insufficient to obtain accurate estimates for any other regions than the West.

NAEP 1992 Trial state Assessment

(Standardized for demographic differences)

Grade 8 Mathematics					
278	North Dakota				
277					
276					
275	Iowa	Minnesota			
274	**New Jersey**	Maine	New Hampshire		
273	Idaho				
272	Connecticut				
271	Massachusetts	Wisconsin			
270	Nebraska	Wyoming	Utah		
269	Texas				
268	Colorado	Pennsylvania	New York	Virginia	Missouri
267	Arizona	California	Maryland	Indiana	Michigan
266	**NATION**				
265	South Carolina	Oklahoma	Ohio		
264	Delaware	New Mexico	Florida		
263	Rhode Island				
262	Georgia				
261					
260	Kentucky				
259	North Carolina				
258					
257	Hawaii	Tennessee			
256					
255	Alabama	Louisiana	Arkansas	West Virginia	
254	Mississippi				

Figure 3. After standardization New Jersey ranks fourth among all participating states in the 1992 8th grade mathematics assessment.

NAEP 1992 Trial state Assessment
(Standardized for demographic differences)

Grade 4 Mathematics						
227	New Hampshire					
226	Maine					
225						
224	Connecticut					
223	**New Jersey**	Iowa	Wisconsin			
222	North Dakota	Pennsylvania				
221	Minnesota	Texas	Wyoming	Virginia	Massachusetts	
220	Nebraska	Missouri	New York			
219	Maryland	Georgia				
218	Colorado	Idaho	Indiana	Michigan	Delaware	Oklahoma
217	**NATION**	Utah	Ohio	Arizona		
216	South Carolina					
215	New Mexico	North Carolina				
214	Rhode Island	Florida				
213	Kentucky					
212	California	West Virginia				
211	Hawaii					
210	Tennessee	Alabama	Arkansas	Louisiana		
209	Mississippi					

Figure 4. The standardized scores for the 41 states in the 1992 4th grade math assessment.

Gain in Mathematics Proficiency from 4th to 8th grade
(Scores are standardized to entire US population)

56	North Dakota
55	California Idaho
54	Minnesota
53	Utah
52	Iowa
51	**New Jersey**
50	Arizona Colorado Florida Massachusetts Nebraska
49	**NATION** Indiana Michigan New Mexico Rhode Island Wyoming South Carolina Ohio Texas
48	Connecticut Maine Wisconsin New York Maryland Missouri
47	Kentucky Oklahoma Virginia Tennessee New Hampshire
46	Delaware Hawaii Pennsylvania
45	Alabama Arkansas Louisiana Mississippi
44	North Carolina
43	Georgia West Virginia

Figure 5. Standardized estimates of change in mathematics performance seen by state between 4th and 8th grade in the 1992 assessment. New Jersey's gain was the seventh largest.

International 1991 Mathematics Assessment
(Predicted Proficiency for 13 year olds)

285	Taiwan	
284		
283	Korea	
282		
281		
280		
279	Soviet Union	Switzerland
278		
277	Hungary	
276		
275		
274	**New Jersey**	
273	France	
272	Italy	Israel
271		
270	Canada	
269	Ireland	Scotland
268		
267		
266	Slovenia	
265		
264		
263	Spain	
262	**United States**	
•		
•		
•		
246	Jordan	

Figure 6. Placing New Jersey explicitly into the 1991 International Assessment shows that its students performed above the average level of most developed nations.

International 1991 Mathematics Assessment

(Predicted Proficiency for 95th %ile of 13 year olds)

345	Taiwan
•	
•	
•	
335	Korea
334	
333	
332	
331	
330	
329	
328	**New Jersey**
327	
326	Hungary
325	
324	Soviet Union
323	
322	Switzerland
321	
320	
319	France
318	
317	Israel Italy
316	Ireland
315	Scotland Canada
314	
313	
312	**United States**
311	Slovenia
310	
309	
308	
307	
306	Spain
•	
•	
•	
296	Jordan

Figure 7. New Jersey's top students rank third in the world in the 8th grade math assessment.