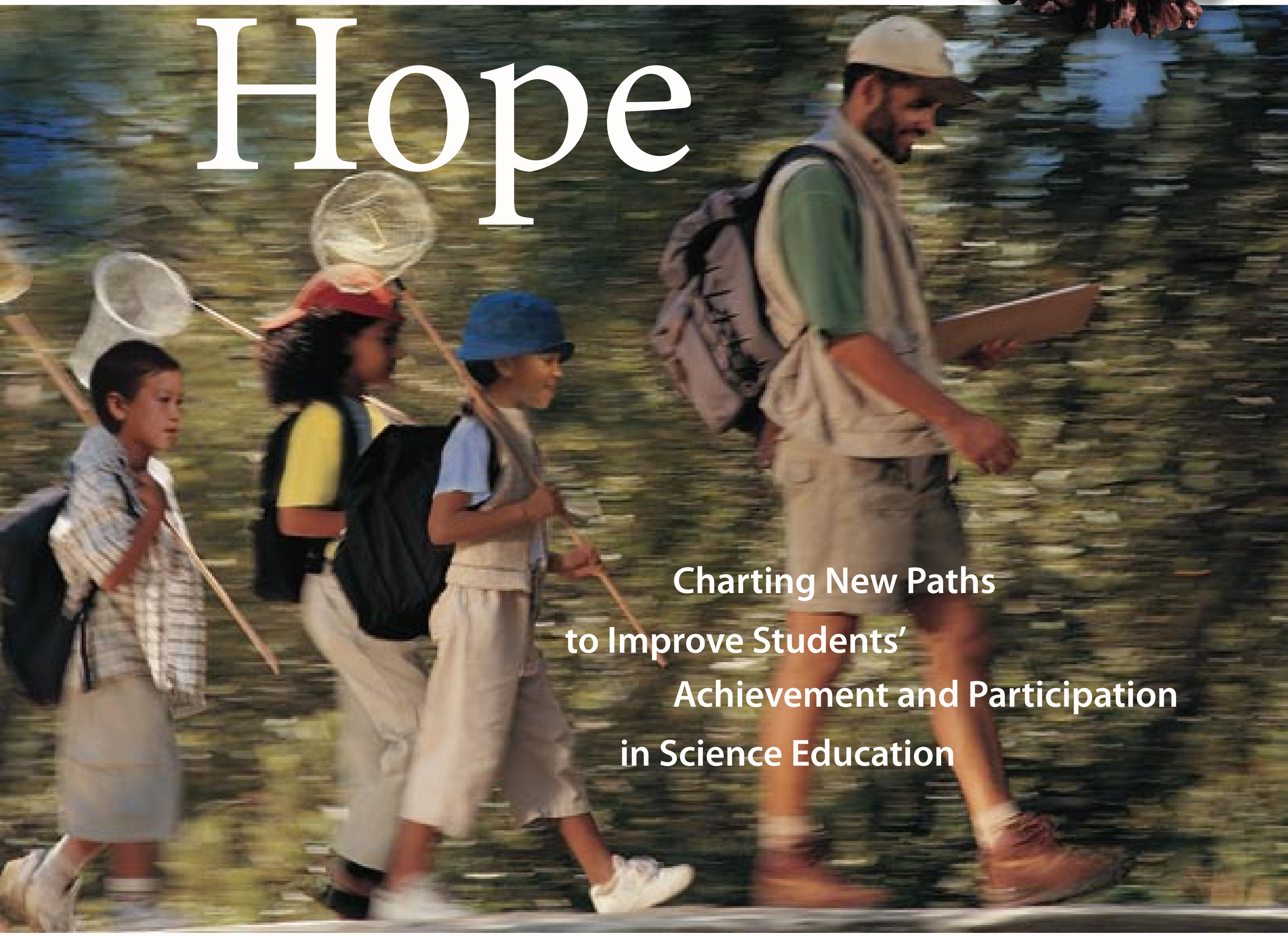
Turning Despondency *into* Hope



Charting New Paths to Improve Students' Achievement and Participation in Science Education

The SOUTHEAST EISENHOWER REGIONAL CONSORTIUM for MATHEMATICS and SCIENCE EDUCATION at SERVE™

Turning Despondency *into* Hope

Charting New Paths
to Improve Students'
Achievement and Participation
in Science Education

Written for SERC@SERVE by
Alberto J. Rodriguez

The SOUTHEAST EISENHOWER REGIONAL CONSORTIUM for MATHEMATICS and SCIENCE EDUCATION at SERVE™

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Contents

Foreword

Global Positioning Satellites, Pentium chips, Human Genome Project, the Internet, Global Economy, National Science Education Standards… and the "Achievement Gap." In the 22 years since I began my quest for a better understanding of racial, ethnic, gender, and socio-economic disparities among those who participate in science (and those who do not), our world has been changed by countless new developments; but the Achievement Gap, acknowledged more than three decades ago, remains. *Turning Despondency into Hope: Charting New Paths to Improve Students' Achievement and Participation in Science Education* is a much-needed resource for a society in which technological advances far outpace our progress in science education reform and our skills in meeting the academic needs of an increasingly diverse student population.

In the introduction to *Mathematics and Science: Critical Filters for the Future of Minority Students* (first published in 1985), the available data allowed me to summarize the situation at that time quite simply: "Black and Hispanic students are scoring below the national norm on science and mathematics achievement tests and are not enrolling in advanced high school mathematics classes in proportion to their numbers in the population.… Because mathematics is a sequential subject and most science and science-related positions require a mathematics background, minority students must be encouraged to begin their mathematics education early and to continue through high school at a minimum."

That monograph represented a novice's attempt to make sense out of a myriad of often unrelated research and reports that spanned a 20-year period. Seeking to arm educators, particularly elementary and middle school principals and teachers, with a research-based understanding of the issues and possible intervention strategies, it identified and summarized then-known variables thought to affect minority student performance in mathematics and science. These variables, clustered into three groups—affective factors, cognitive factors, and classroom/instructional factors—included attitudes toward and stereotyping of these disciplines, perceived utility of mathematics and science, influence of significant others, persistence, previous experiences, academic deficiencies, language, misuse of testing/test data, learning styles, teacher expectations, teacher anxiety about mathematics and science, and instructional practices.

In this new monograph, *Turning Despondency into Hope: Charting New Paths to Improve Students' Achievement and Participation in Science Education*, Alberto Rodriguez, a strong advocate for equity in science education, takes full advantage of recent studies and reports to explore academic trends, provide a deeper understanding of the relevant factors, describe promising practices, and explore relevant issues emerging from the No Child Left Behind Act. He opens with a discussion of a significant—but too often ignored—ray of hope: many teachers and school administrators really DO want their Latina/Latino, African American, and Native American students to achieve; they are desperate for direction and sufficient support; and reports of national studies are now acknowledging that these and other teacher-related contextual and systemic issues must be addressed as part of education reform policies and practices.

To many readers—whether they be concerned with policy, practice, or equity—Dr. Rodriguez' comparative review of the most recent data from the National Longitudinal Study (NELS), the National Assessment of Educational Progress (NAEP), and the Third International Mathematics and Science Study (TIMSS), can serve as a cohesive resource on trends. We usually read these kinds of reports individually, but his analysis across three major assessment programs (with appropriate caveats) quite effectively highlights for even the busiest reader, current trends in mathematics and science performance by gender, race/ethnicity, and socioeconomic status. Similarly, from time to time, we have read of research that suggests effective intervention strategies, but the information is frequently offered in "sound bites" and without sufficient context, and seldom as part of a comprehensive program. However, Dr. Rodriguez' update on the factors affecting student achievement, summary of their cumulative effects as well as his "Promising Cases of School Reform" are presented in a way that can encourage the reader to not only think about the whole picture, but to consider the implications for his or her own work.

When I think about my own work, I am deeply disturbed that data on underserved students continue to tell us that, while there has been some progress, their performance and participation in science, and the contributing factors, have not changed dramatically since 1985. Of particular concern is what appears to be the dearth of research on the science education of African American and Native American students. We have a myriad of test scores, but too little understanding of what successful science education reform would look like for this country's oldest minority populations and effective strategies for achieving it. Clearly, there is much that remains to be done if we are to have a solid research base on which to build sustainable reform for ALL students.

Nevertheless, *Turning Despondency into Hope* offers us much solid information, far more than was available back in 1985. We can choose to forge ahead from a position of hope, using wisely what has been learned, partnering with informed researchers for what we have yet to understand, or we can wring our hands in despair. I love Dr. Rodriguez' optimism as he calls us to be proactive. This monograph offers tools for understanding and action. The tough question is "What will we do with this information?" The degree of proactiveness in our response will be evident 30 years hence when the majority of the students—and quite probably the workforce—will be comprised of people from today's underserved populations.

Thank you, Dr. Alberto Rodriguez, for the hard facts and the hope that you offer here!

Thank you, Dr. Francena Cummings, Director of the Mathematics and Science Consortium at SERVE, for recognizing the need and supporting the development of this monograph.

DeAnna Banks Beane, Director,
Partnerships for Learning Association of Science—Technology Centers Incorporated
December, 2003

Preface

Over 20 years ago, I began working with schools to improve minority students' participation and achievement in mathematics and science. As I began this work, the one practical tool that served as a template for thinking about this topic was *Mathematics and Science: Critical Filters for the Future*. In this document, Beane (1985) described research-based factors that influenced the achievement and participation of minority students. (See Foreword by Beane in this document.) These factors informed the framework that was used to design the Mathematics, Science, and Minorities K-6 Project (MSM: K-6 Project), a project I coordinated in my local school district. This project was implemented in three school districts with tremendous success. A glimpse of this success is described in the following:

> Not only was change evident in those MSM: K-6 Project principals, teachers and guidance counselors who worked so diligently on their school-based leadership teams, but their schools also changed. African American and Hispanic students in most of these schools were no longer "listening to and watching mathematics and science," they were **doing** mathematics and science. In fact, **all** students benefited from the changes. (Denbo, 1992 p. v)

As director of the Southeast Eisenhower Regional Consortium, my world-view related to working with schools to improve mathematics and science was shaped by my work with this project. Therefore, equity has always been the lens for the Consortium's products and services. In recent years, our review of recent documents on the achievement gap continued to indicate that minority student participation and achievement in science and mathematics lag behind that of white and Asian students. These results were both disappointing and disturbing, and they became the drivers for commissioning a document that examines specific research related to minority student participation and achievement in science.

Mary Budd Rowe believed that science could play a powerful role in determining the destiny of a people. In her early work with urban students, she offered the following comment:

> Probably the single greatest contribution which early education in science can make to a people is the development of a belief based on evidence, that they can to some extent influence the direction and quality of their destiny.
>
> —Mary Budd Rowe, 1974, cited in *Mathematics and Science: Critical Filters for the Future*, 1985

I agree with Rowe's disposition that science provides a place for students to begin thinking about how they can control and/or influence the quality of their destiny.

Alberto Rodriguez's document *Turning Despondency into Hope: Charting New Paths to Improve Students' Achievement and Participation in Science* shines light on recent research reports that highlight trends related to academic achievement. He offers hope for improving achievement and participation and closing the achievement gap through a description of promising practices in science. Our hope is that science educators will find this document a valuable resource for improving the science education experiences of all students and for creating opportunities for underserved students to enhance their destinies.

Francena D. Cummings, Director
Southeast Eisenhower Regional Consortium

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Rowe, M. B. (1974). Relation of wait time and rewards to the development of language, logic and fate control. *Journal of Research in Science Teaching, 11*, 299.

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The author is indebted to the reviewers for their insightful comments and suggestions. The contributions of all of those who attended the Special Issues Forum to discuss this monograph are also very much appreciated.

Your passionate interest in enhancing the educational opportunities of traditionally underrepresented students in science was a source of inspiration, and I hope your valuable suggestions are well represented here.

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Introduction

Consider this letter written by a teacher in response to an article published in *NEA Today*[1] about my research on trends in student achievement and participation in science and mathematics (Rodriguez, 1998a):

> I read the article about your research in the latest issue of *NEA Today*. Needless to say, those of us who have worked with Hispanic students have known some of these things for a long time, but we don't know what to do about it. I was excited to see the article.
>
> I am a member of our school improvement team, and we have just recently looked at…[our] scores for the district. We are a district in southeastern Iowa, and our Hispanic population runs about 20% or so. The scores for our Hispanic students tend to be 10 percentile points below the district average, and when we get to high school, they are only about half. We are at a loss as to what to do. One outspoken parent made a suggestion to me that we just retain the students until they are ready to go on. Now, if you knew me, you would know that it was no small feat that I maintained my cool with this comment and politely informed her that this was not a good option.
>
> I was wondering if you could possibly send me some concrete ideas of things that would be better options to look into and research.… I think the district is ready to do something, but I don't want to just pass it off as low socioeconomic status or test bias. I know these things figure in, but I think there is a lot more to it that we aren't doing.…I would appreciate any help you could offer.
>
> Chris Clark,
> ESL/Science Teacher from Iowa[2]

The sense of urgency and frustration in this teacher's voice is as strong as his obvious desire to do something different—something that could really help narrow the gap in student achievement and participation at his school. While many teachers, like Chris, hope for concrete suggestions to effect long-lasting change in their schools, most of the literature on student achievement and participation focuses on depressing narratives of despair. These narratives offer little or no guidance on how to implement the complex, risky and demanding changes that must take place to improve the academic performance of traditionally underrepresented students[3] in today's schools.

This monograph aims to provide a more positive outlook on the future of science education reform by offering new insights and concrete suggestions for change based on the analysis of recent reports and promising field-based studies. This does not imply that we should avoid paying attention to those who warn us about the undeniable social, economic and political

1 The National Education Association's magazine, Jan. 1999 issue.

2 This letter was first published in Rodriguez, A. J. (2001a).

3 Traditionally underrepresented students in science include women and students from Latino/a (Hispanic), African American (Black), Native Americans (First Nations) ethnic backgrounds, and students from disadvantaged socioeconomic status. See the Appendix for a description of terms used.

conundrum our country is going to experience if we do not improve the access to and success rate of traditionally underrepresented students in science courses. In this report, I heed these warnings by offering a realistic look at current trends in student achievement and participation and the many factors that serve to sustain them. But, instead of stopping there and adding to the narratives of doom and gloom, a narrative of hope and possibility is offered.

To this end, I start with a short review of key national reports that provide more specific suggestions for bringing about change. These reports do highlight legitimate threats to our economic, social and political stability, but at the same time, they move beyond just ringing the same alarm that has been rung in the last three decades. This section is followed by an update on trends in student achievement and participation by gender and by ethnic groups. Key reports, such as the recently released National Assessment of Educational Progress (NAEP) and the Third International Mathematics and Science Study (TIMSS), are included in the discussion in order to explore whether so many years of intensive school reform efforts in various parts of the country have had any impact on student performance and/or teachers' practice.

After an update on the achievement trends, it is only appropriate to offer a review of what many researchers and teachers consider to be the key factors affecting this issue. This review focuses on exploring whether anything has changed after three decades of research have pointed out repeatedly the factors that impact how students learn and how teachers teach.

To meet one of the major goals of this monograph, an analysis is provided of some key school-based studies that are either very promising or have already had a significant and positive impact on student performance and teaching practice. A summary of promising strategies for enhancing the academic achievement and participation of traditionally underrepresented students concludes the monograph. I hope that readers will take into their own contexts a message of hope and possibility after reading this analysis—for the suggestions provided here will require more than good intentions to implement. They will require political will to face risks, emotional capital to sometimes stand alone in a crowd, and courage to make the first two even possible and to bring about long-lasting change in today's schools.

Doom and Gloom vs. Hope

It is now well known that after the former Soviet Union put Sputnik into orbit in 1957, a massive wave of school reform in mathematics and science was launched in the United States. It seems that four and a half decades later, we are still swept by this wave since all sorts of school reform efforts continue to be proposed (or expected). Yet, many of these reform initiatives are being attempted without a reliable compass or an effective map. This was evident, when in 1983, the alarm was sounded again loud and clear with the release of the much-publicized report, *A Nation at Risk: The Imperative for Education Reform*. Members of the Commission on Excellence in Education, who prepared this report, put it boldly when they stated that a "rising tide of mediocrity" was flooding U.S. schools. Their solution? To have students spend more time learning science and mathematics by increasing the number of required courses in these subjects for high school graduation. To this call, most states responded positively by doing just as expected.

However, ten years after the *Nation at Risk* report's recommendations, Blank and Engler (1992) found that the report had little effect on the previous trends in student achievement. These trends, past and present, will be discussed in more detail in the next section. What is important to highlight here is that the lack of success of various reform efforts for the last four decades has left many frustrated and pessimistic about the future of education in this country. This sense of gloom and doom is clearly reflected in the title of recent reports and books such as, *The Predictable Failure of Educational Reform* (Saranson, 1999), *Is Student Achievement Immutable?* (Suter, 2000), or *The Sharp Edge of Educational Change* (Bascia and Hargreaves, 2000).

But there is hope. Some reports being prepared by national task forces are beginning to finally acknowledge how limited resources and the diverse socio-cultural contexts in which teachers are expected to work play key roles in how and what teachers teach and in what students learn. For example, the National Commission on Teaching and America's Future (NCTAF, 1996), in sharp contrast to the *Nation at Risk* report, states:

> After a decade of reform, we have finally learned in hindsight what should have been clear from the start: Most schools and teachers cannot produce the kind of learning demanded by the new reforms—not because they do not want to, but because they do not know how, and the systems in which they work do not support them in doing so… Successful programs cannot be replicated in schools where staff lack the know-how and resources to bring them to life. Wonderful curriculum ideas fall flat in the classroom where they are not understood or supported by the broader activities of the school. And increased graduation and testing requirements only create greater failure if teachers do not know how to teach students so that they can learn (p. 5).

To address these issues, the National Commission on Teaching and America's

Future (NCTAF, 1996) put forward three basic principles to guide their comprehensive plan of recommendations[4]:

- What teachers know and can do is the most important influence on what students learn.
- Recruiting, preparing, and retaining good teachers is the central strategy for improving our schools.
- School reform cannot succeed unless it focuses on creating the conditions in which teachers can teach and teach well (NCTAF, 1996, p.vi).

The first principle would have faired very well with John Dewey, who over 100 years ago emphatically explained the key roles teachers' preparation and abilities play in students' learning:

> No matter what is the accepted precept and theory, no matter what the legislation of the school board or the mandate of the school superintendent, the reality of education is found in the personal and face-to-face contact of the teacher and child. The conditions that underlie and regulate this contact dominate the educational situation (Dewey, 1901, cited in Kliebard, 1992, p. 103).

The second principle is based on the alarming fact that over two million teachers will be needed in the next decade, yet teacher attrition rates and low teacher salaries continue to work against meeting this goal. Finally, the third principle points out that well-intended policies or comprehensive documents like the National Science Education Standards cannot be enacted without the corresponding financial, structural, and professional development support.

This sentiment is echoed by another more recent report, *Before It's Too Late: A Report to the Nation from the National Commission on Mathematics and Science Teaching* (Glenn, 2000), spearheaded by former astronaut John Glenn. Despite its ominous title, this report, too, is a ray of hope as it describes some concrete suggestions for effecting change at a system-wide level.

[4] Instead of rehashing the specific recommendations being proposed by this and other national commissions here, I will contrast some of these key recommendations with the promising reform efforts being implemented in various schools around the country. The reader is encouraged to read the full commission reports for more details on their strategies for action.

This Commission also uses strong and direct language to explain that "two decades of experience in education reform demonstrate that tinkering around the edges will not suffice" (p. 16). And, like the National Commission on Teaching and America's Future, members of the Glenn Commission based their recommendations on available research rather than well-intended rhetoric.

At the core of the Glenn Commission report, the enhancement of teacher preparation, retention, and recruitment are also perceived as key factors in improving the academic performance and participation of all students in science and mathematics. In fact, this Commission proposes three broad goals (along with a $5 billion budget and strategies for implementation):

- Establish an ongoing system to improve the quality of mathematics and science teaching in grades K–12.
- Increase significantly the number of mathematics and science teachers and improve the quality of their preparation.
- Improve the working environment and make the teaching profession more attractive for K–12 mathematics and science teachers (p. 5).

Considering that most of the teachers who leave the teaching profession cite "dissatisfaction" with their working environment as one of the main reasons for quitting (Glenn, 2000), Goal #3 should help ameliorate this pervasive problem. More details on the factors that influence the trends in student achievement and participation will be provided later, but now it is important to highlight three common themes between these two key reports and the more recent literature on school reform. First of all, these national commissions for the first time are acknowledging—and making specific suggestions to address—the fact that the socio-cultural contexts in which teachers are expected to teach are as important as the availability of sufficient resources to teach well. In short, one not only needs to crack eggs to make an omelet, one must have access to eggs, equipment and the expertise necessary to do the expected job well. Second, for math and science reform efforts to be long lasting, deep analyses of educational research must be our compass. And third, our educational reform map must be collaboratively constructed with the effective representation of the stakeholders who are familiar with the unique socio-cultural landscape of each school (i.e., teachers, students, parents, administrators and members of the community).

So what are the current trends in student achievement and participation in science that after three decades of school reform efforts, after the work of several commissions, and after the publication of various reports, we are still haunted by the same issues?

Another Look at the Trends in Student Achievement and Participation in Science Education:

Where Are We Heading?

Three major educational attainment projects will be contrasted to explore current trends in student achievement and participation in the U.S. These projects are: the National Education Longitudinal Study (NELS), the National Assessment of Educational Progress (NAEP), and the Third International Mathematics and Science Study (TIMSS).

NELS Trends

The Office of Educational Research and Improvement is in charge of the National Education Longitudinal Study or NELS (Horn, Hafner, & Owings, 1992; Owings, & Peng, 1992; Rock, & Pollack, 1995). One of the goals of this study was to measure cognitive growth in science over time. The NELS also aimed to investigate the impact of school policies, family participation, and teacher practice on educational outcomes as the students developed and made challenging transitions from middle school, to high school, to college.

In its base year, 1988, the National Education Longitudinal Study (NELS) involved 25,000 eighth-graders from over 1,000 randomly selected schools across the nation. In addition, NELS gathered information from students, their parents, teachers and school administrators. In this monograph, I will contrast the results of two of the follow-up studies of the 1988 eighth-grade cohort, which were conducted in 1990 and 1992, respectively.

Findings from the NELS's base year and first follow-up indicate that all ethnic groups showed improvement in their science performance scores in the first follow-up (Table 1; Scott, Rock, Pollack, & Quinn, 1995); however, the gap in achievement was maintained between Anglo-European and Asian students and African American and Latino/a students. Moreover, the U.S. Anglo and Asian students showed the most gain in average scores (by half to three quarters of a standard deviation) in comparison to African American and Latino/a students.

Table 1 National Education Longitudinal Study 1988 average science scores vs. 1990 average scores by ethnicity, gender, and socioeconomic status

		1988		1990	
	Sample Size	Mean	S.D.	Mean	S.D.
Total Sample	15222	11.730	4.354	14.009	5.034
Ethnicity					
Asian	933	12.198	4.588	14.956	5.211
Hispanic	1719	9.840	3.469	11.666	4.280
African American	1450	9.083	3.347	10.467	4.036
Anglo-European	10938	12.410	4.348	14.874	4.900
Gender Groups					
Male	7517	12.172	4.594	14.664	5.267
Female	7705	11.289	4.052	13.355	4.701
SES Quartiles					
SESQ1 (Low Quartile)	3099	9.532	3.412	11.237	4.238
SESQ2	3642	10.974	4.029	12.995	4.765
SESQ3	3790	12.059	4.191	14.362	4.750
SESQ4 (High Quartile)	4691	13.730	4.465	16.642	4.705

Source: Scott et al. (1995)

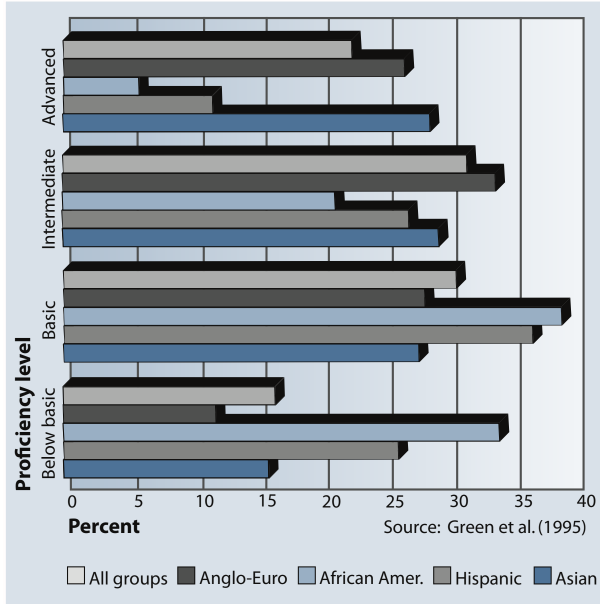
In addition, Table 1 shows that males not only outperformed females in both the base year and first follow-up tests (by one-fifth of a standard deviation), but they also showed the larger gains in scores (Scott et al, 1995). This table also illustrates the pattern of achievement according to the students' socioeconomic status. Students from the top SES quartile obtained higher scores and showed the most gains over time.

The NELS's second follow-up in 1992 with grade 12 students was more detailed and allowed for a more in-depth analysis of academic growth (Green, 1995). Students were given four cognitive tests in reading, science, mathematics and history/government. The scores were interpreted according to the following four-level proficiency scale:

- **Below Basic**: No demonstration of understanding everyday science concepts.
- **Basic**: Understanding of everyday science concepts; "common knowledge" that can be acquired in everyday life
- **Intermediate**: Understanding of fundamental science concepts upon which more complex science knowledge can be built
- **Advanced**: Understanding of relatively complex scientific concepts, typically requiring an additional problem-solving step

Figure 1 illustrates that only 11% of Latinos/as and 5.4% of African American students attained the advanced proficiency level; whereas slightly over 28% of U.S. Asian and 26.3% of the Anglo-European students scored at the advanced level of science proficiencies. On the other hand, the pattern reverses dramatically at the below basic level with 34.5% of African American and 25.8% Latino/a students scoring at this level. Note that the achievement gap is narrower among all underserved students at the Intermediate level (Table 2 includes the statistical data for the information shown in Figures 1 to 3.)

Figure 1 Percent of 1992 NELS high school seniors by science proficiency level and by ethnic group



In regard to gender differences, the NELS does not provide data on the performance score distribution by gender within ethnic groups. In a previous analysis of trends in student achievement, I argued that it is imperative for researchers, national institutes and organizations to avoid reporting student achievement by homogenizing categories (Rodriguez, 1998a). That is, lumping the academic performance of girls and women from various ethnic backgrounds and socioeconomic status into one single "female"

Table 2 Percent of 1992 NELS high school seniors demonstrating proficiency at various levels of science by ethnicity, gender, and socioeconomic status

Group	Below basic	Basic	Intermediate	Advanced	Unweighted N
Total	16.4 (.63)	30.2 (.59)	31.1 (.69)	22.3 (.67)	11623
Gender					
Male	14.7 (.93)	29.3 (.84)	29.8 (1)	26.1 (.92)	5834
Female	18.1 (.72)	31.0 (.82)	32.6 (.87)	18.3 (.86)	5789
Ethnicity					
Asian	15.3 (2.09)	27.5 (2.61)	29.0 (2.58)	28.2 (2.44)	808
Hispanic	25.8 (1.7)	36.4 (2.05)	26.7 (1.63)	11.0 (1.31)	1324
African American	34.5 (2.69)	39.1 (2.21)	21.0 (1.96)	5.4 (.79)	1053
Anglo-European	12.1 (.59)	28.1 (.66)	33.5 (.83)	26.3 (.79)	8299
Socioeconomic Status					
Low	28.2 (1.17)	39.5 (1.23)	23.9 (1.07)	8.5 (.67)	2794
Medium	14.7 (.8)	32.0 (.85)	32.4 (.95)	20.9 (.82)	5512
High	7.6 (1.2)	17.5 (.88)	36.0 (1.53)	38.9 (1.63)	3270

Note: Standard errors of estimated percentages are shown in parentheses. Source: Green et al. (1995)

Figure 2 Percent of 1992 NELS high school seniors by proficiency level and by gender

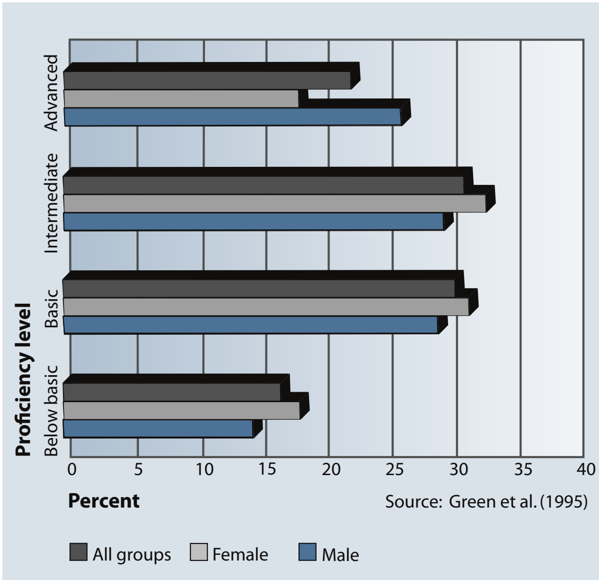
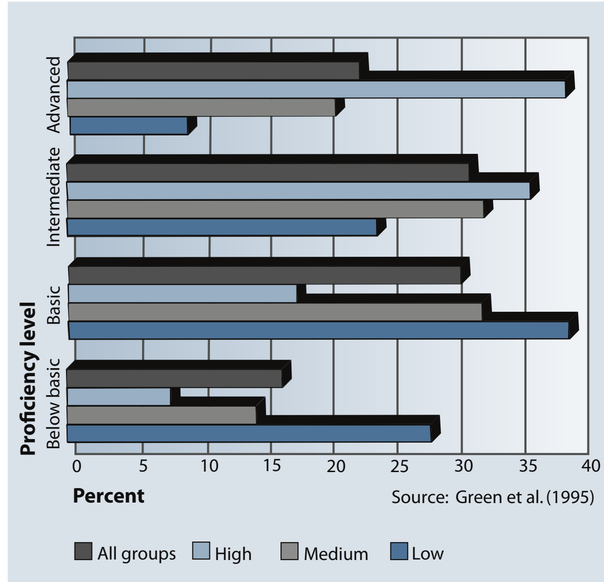


Figure 3 Percent of 1992 NELS high school seniors by proficiency level and by socioeconomic status



category. Similarly, researchers should avoid lumping the academic performance of richly diverse ethnic groups such as Latinas/os into one general "Hispanic" category. As mentioned earlier, Latinos/as could be of any skin color and/or could come from any of the major Latino ethnic groups in the U.S. such as Chicano/a, Mexican American, Latin American, or Puerto Rican. Some improvement in the reporting of student academic performance and participation has been made in recent years, and this approach could lead us to better understandings of the unique struggles and successes students face in their schooling by gender *within* ethnic groups (Rodriguez, 1998a).

Given the aforementioned limitations, the differences in achievement between males and females are shown in Figure 2. Males dominate the advanced proficiency level by almost eight percentage points, whereas females are slightly ahead at the Intermediate level by almost 2.5 percentage points. By combining the percentage of students who scored at the basic and below basic levels, we see that 49% of the female high school seniors do not understand fundamental principles of science, whereas 44% of the males are in the same predicament (see Table 2 and Figure 2).

This trend in achievement is also shown in the score distribution according to socioeconomic status. That is, almost 68% of students from low-income families and 47% of students from medium-income families do not appear to understand the fundamental principles of science (see Figure 3 and Table 2). On the other hand, 75% of high-income students scored at the intermediate and advanced proficiency levels.

Now, let's contrast these trends in student achievement with the scores reported by the National Assessment of Educational Progress.

NAEP Trends

The National Center for Education Statistics manages the National Assessment of Educational Progress (NAEP) project. This has probably been the most comprehensive tool for assessing students' cognitive achievement in science and mathematics at critical grade levels since 1969 (Mullis, Dossey, Campbell, Gentile, O'Sullivan, & Latham, 1994).

Essentially, the NAEP evaluates the academic achievement of a nationally representative sample of elementary (grade 4) and secondary (grades 8 and 12) students in science, mathematics, reading, writing, history, civics, and geography. Since the NAEP underwent major changes in 1996, the NAEP scores from previous years cannot be directly compared. However, the trends in student achievement from the 1970 to 1992 NAEP tests will be briefly discussed here because they add a richer understanding of students' academic performance by gender and ethnic group on the revised NAEP tests.

Table 3 Average NAEP science scores and standard errors of estimated proficiencies per age group 1970–1992

	1970	1973	1977	1982	1986	1990	1992
Age 17	305 (1.0)	296 (1.0)	290 (1.0)	283 (1.2)	288 (1.4)	290 (1.1)	294 (1.3)
Age 13	255 (1.1)	250 (1.1)	247 (1.1)	250 (1.3)	251 (1.4)	255 (0.9)	258 (0.8)
Age 9	225 (1.2)	220 (1.2)	220 (1.2)	221 (1.8)	224 (1.2)	229 (0.8)	231 (1.0)

Note: Standard errors of estimated proficiencies are shown in parentheses.

Source: Mullis et al. (1994)

Trends in Student Achievement: Original NAEP 1970–1992

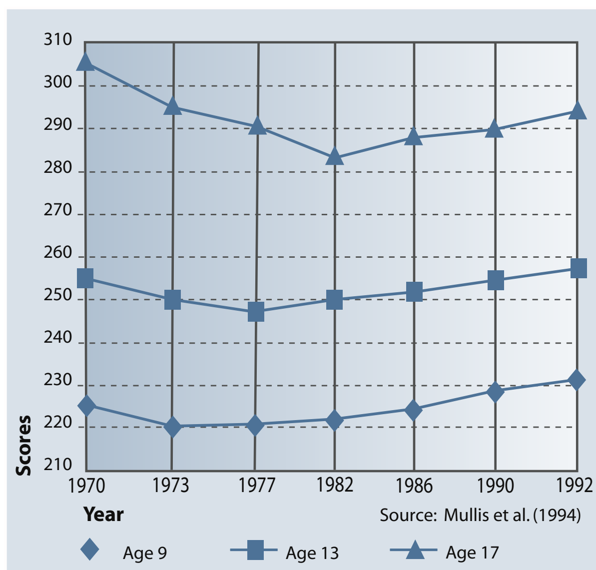
The original NAEP study was designed to draw from a representative sample of the student population in grades 4 (age 9), 8 (age 13), and 12 (age 17). For example, in 1990, approximately 45,000 students per grade participated in the assessment. To facilitate interpretation of NAEP scores, students' performance was assessed according to a five-level proficiency scale (Mullis et al, 1994) as follows:

- **350**—Student can infer relationships and draw conclusions using detailed scientific knowledge.
- **300**—Student has some detailed scientific knowledge and can evaluate the appropriateness of scientific procedures.
- **250**—Student understands and applies general information from the life and physical sciences.
- **200**—Student understands some simple principles and has some knowledge, for example, about plants and animals.
- **150**—Student knows everyday science facts.

Figure 4 illustrates that, compared to 1970 scores, the average science achievement for all students who participated in the 1992 NAEP (Mullis et al, 1994) was slightly higher for nine-year-olds, practically the same for 13-year-olds, and lower for 17-year-olds. (The standard errors for the estimated proficiencies are shown in Table 3.) Though it may not appear so, this bad news hides some good news. The overall science performance for all three age groups actually increased from 1982 to 1992.

In the last 20 years, according to NAEP (Mullis et al, 1994), the gap in science performance scores of students of African American, Latino/a, and Anglo-European descent[5] closed modestly from 1977 to 1986. From 1986 to 1992, however, the achievement gains of underserved students seemed to have stalled (see Figures 5 and 6). Furthermore, in spite of some improvement, the differences in academic performance among ethnic groups are still quite large for all three age groups considered. For example, in 1992 the gaps in proficiency scores among students from Anglo-European and African American ethnic backgrounds were 48 points for 17-year-olds, 43 points for 13-year-olds and 39 points for nine-year-olds[6] (see Figure 5 and Table 4).

Figure 4 Trends in U.S. students' achievement in science: National Assessment of Educational Progress (NAEP) 1970–1992



[5] The original NAEP study only reported the academic achievement of these three ethnic groups. The revised NAEP now includes the scores of Asian and Native American students.

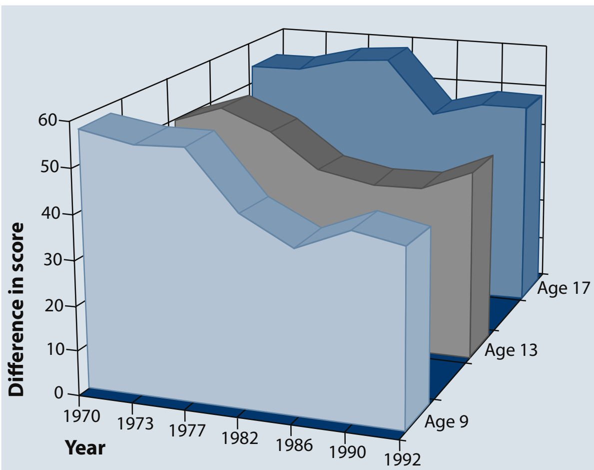
[6] Note that figures 5 through 7 are for illustration only. These figures were created by doing simple subtractions of the students' scores. No statistical claim is being made about these differences.

Table 4 Average 1970 NAEP science scores vs. 1992 average scores by age, ethnicity and by gender

	Age 9		Age 13		Age 17	
	Proficiency in 1970	Proficiency in 1992	Proficiency in 1970	Proficiency in 1992	Proficiency in 1969	Proficiency in 1990
Nation	255 (1.2)	231 (1.0)	255 (1.1)	258 (0.8)	305 (1.0)	294 (1.3)
Anglo-European	236 (0.9)	239 (1.0)	263 (0.8)	267 (1.0)	312 (0.8)	304 (1.3)
African American	179 (1.9)	200 (2.7)	215 (2.4)	224 (2.7)	258 (1.5)	256 (3.2)
Hispanic	192 (2.7)	205 (2.8)	213 (1.9)	238 (2.6)	262 (2.2)	270 (5.6)
Male	228 (1.3)	235 (1.2)	257 (1.3)	260 (1.2)	314 (1.2)	299 (1.7)
Female	223 (1.2)	227 (1.0)	253 (1.2)	256 (1.0)	297 (1.1)	289 (1.5)

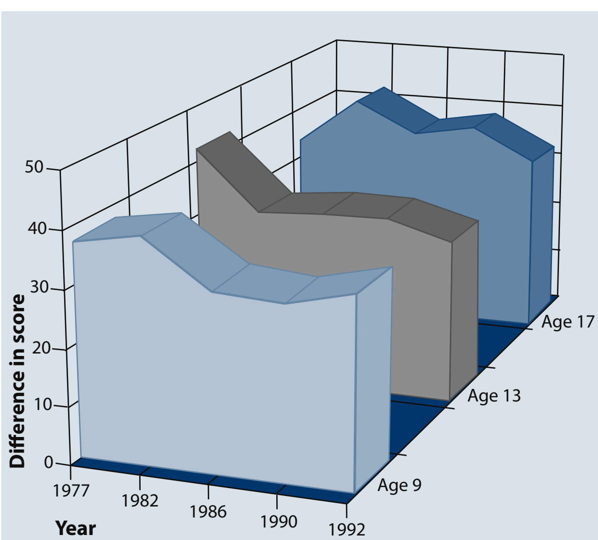
Note: Standard errors of estimated proficiencies are shown in parentheses. Source: Mullis et al. (1994)

Figure 5 Differences in NAEP proficiency scores: U.S. Anglo minus African-American scores



Source: Mullis et al. (1994)

Figure 6 Differences in NAEP proficiency scores: U.S. Anglo minus U.S. Latina/o scores

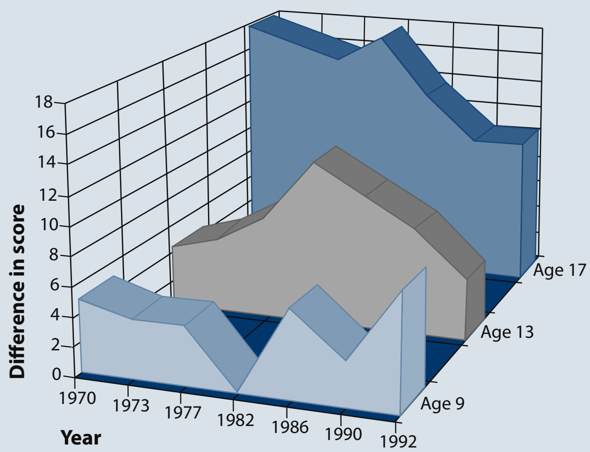


Source: Mullis et al. (1994)

A similar pattern of achievement was observed between Latina/o students and Anglo-European students (i.e., a gap of 34, 30, and 34 points per grade level, respectively; see Figure 6 and Table 4). Nevertheless, as Figure 6 shows, the gap in achievement between Anglo and Latino/a students continued to shrink at ages 13 and 17.

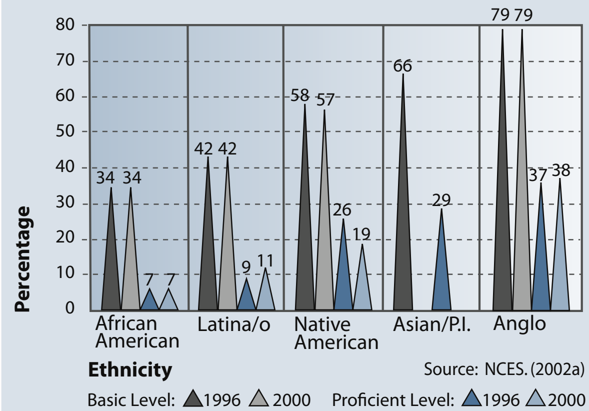
The gender difference in the average proficiency scores between 13- and 17-year-old males and females seems to be decreasing (Figure 7). The differences in 1992 scores were 10 points for 17-year-olds, four points for 13-year-olds and eight points for nine-year-olds. Interestingly, while both males and females made some gains in the last decade, males continue to have higher scores at all three age levels since 1970. These patterns should be interpreted with caution since none of the differences in scores by gender and by age have been statistically significant since 1969–70.

Figure 7 Differences in NAEP Proficiency scores: male minus female scores



Source: Mullis et al. (1994)

Figure 8 Percentage of students at or above Basic and Proficient levels by ethnicity Grade 4—NAEP 1996 vs. 2000



Note: Due to technical issues, the NCES did not include the NAEP 2000 scores for Asian/P.I. Students.

Figure 9 Percentage of students at or above Basic and Proficient levels by ethnicity Grade 8—NAEP 1996 vs. 2000

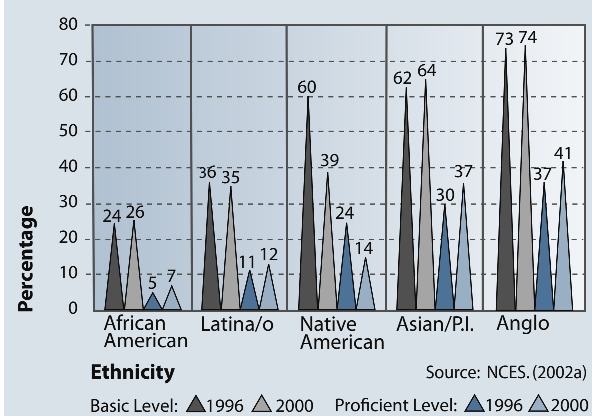
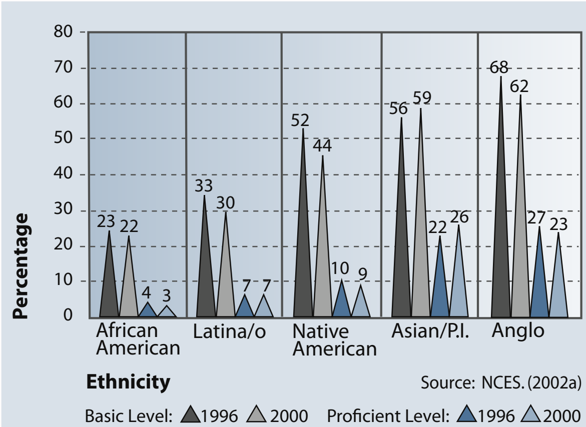


Figure 10 Percentage of students at or above Basic and Proficient levels by ethnicity Grade 12—NAEP 1996 vs. 2000



Has the pattern in student achievement changed now that a new and improved NAEP has been put in place since 1996? Next, I contrast the revised NAEP 1996 vs. 2000 scores with the original NAEP results.

Trends in Student Achievement: Revised NAEP 1996–2000

Since its revision, the NAEP has been administered twice—once in 1996 and again in 2000. Similarly to the original version of this test, the revised NAEP 2000 involved a representative random sample of 47,000 students from 2,100 schools (including non-public schools). A new scale was created to determine students' achievement levels as follows:

- **Basic**—Student has partial mastery of prerequisite knowledge and skills that are fundamental for proficient work at each grade.
- **Proficient**—Student demonstrates solid academic performance for each grade level assessed. Students reaching this level have demonstrated competency over challenging subject matter, including subject-matter knowledge, application of such knowledge to real-world situations, and analytical skills appropriate to the subject matter.
- **Advanced**—Student demonstrates superior performance (NCES, 2002).

Table 5 **Percentage of students at or above *Basic* and *Proficient* by ethnicity Grade 4, 8, and 12: 1996–2000**

	Grade 4				Grade 8				Grade 12			
	1996		2000		1996		2000		1996		2000	
	Basic	Prof	Basic	Prof	Basic	Prof	Basic	Prof	Basic	Prof	Basic	Prof
Nation	58	26	57	19	60	24	39	14	52	10	44	9
Anglo-European	79	37	79	38	73	37	74	41	68	27	62	23
African American	34	7	34	7	24	5	26	7	23	4	22	3
Hispanic	42	9	42	11	36	11	35	12	33	7	30	7
Male	68	31	69	33	62	31	64	36	60	29	54	21
Female	67	27	64	26	61	27	57	27	55	17	51	16

Note: Standard errors were not available per ethnic group.

Source: National Center for Education Statistics. (2002a)

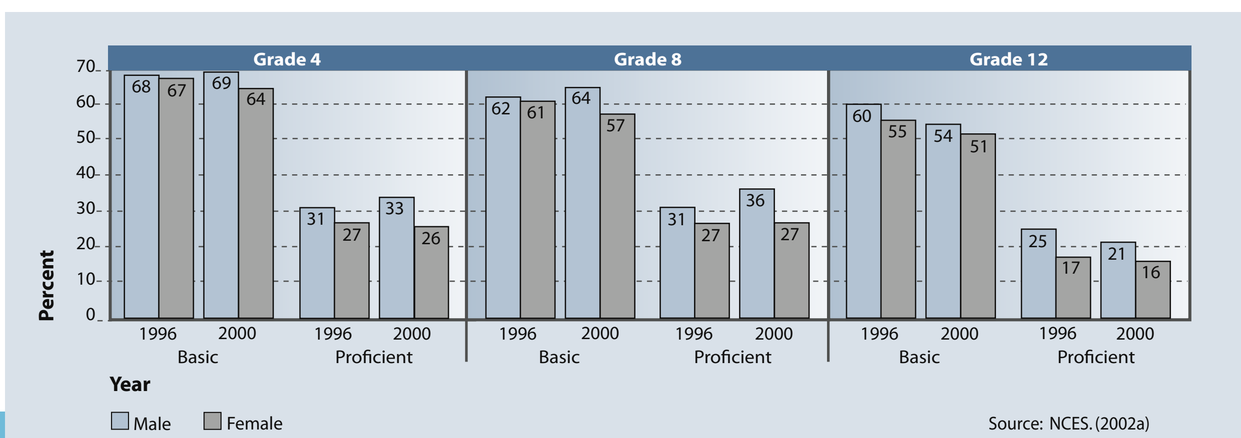
Figures 8 through 11 clearly indicate that there has been little change in the pattern of student achievement by ethnicity and by gender between the 1996 and 2000 NAEP tests. Furthermore, exactly the same pattern of achievement—with similar wide gaps in performance—is observed between the original and revised NAEP tests (contrast Figures 4 through 7 with Figures 8 through 11).

For example, starting with Figure 8, one can observe that 79% of the Anglo grade 4 students who took the '96 NAEP test outperformed students from all other ethnic groups at the *Basic* level. The second highest scoring ethnic group was the U.S. Asian/Pacific Islander (66%), followed by Native American students (59%), Latinos/as (42%) and African American students (24%). There was no statistical significance change in the pattern and magnitude of achievement among these ethnic groups for the year 2000 NAEP (NCES, 2002a).

Figure 8 also shows the students' performance at the *Proficient* level (see scale above). Again the same pattern of achievement—with similar wide gaps in performance among ethnic groups—is observed. Whereas 37% and 38% of Anglo grade 4 students scored at the *Proficient* level for the 1996 and 2000 NAEP, respectively, much smaller percentages of Latinos/as and African American students performed well at this level for the same years (NCES, 2002a).

In terms of gender differences, Figure 11 illustrates the percentage of male and female students performing at or above the *Basic* and *Proficient* NAEP levels for 1996 and 2000. As the graph illustrates, there was practically no change in the pattern of achievement. That is, males scored higher than females at the *Basic* and *Proficient* levels for all three grades. The only statistical significance change was observed at grade 12 where the male students' score dropped from 69% at or above *Basic* in 1996 to 54% in 2000 (NCES, 2002a).

Figure 11 **Percentage of students at or above Basic and Proficient NAEP levels by gender and by grade**



Other important statistically significant changes were observed for the overall grade 8 and grade 12 males' average scores. At grade 8, male students' score increased from 151 points[7] in '96 to 154 in '00. Grade 12 male students' score, on the other hand, decreased from 152 points to 148 in the same years.

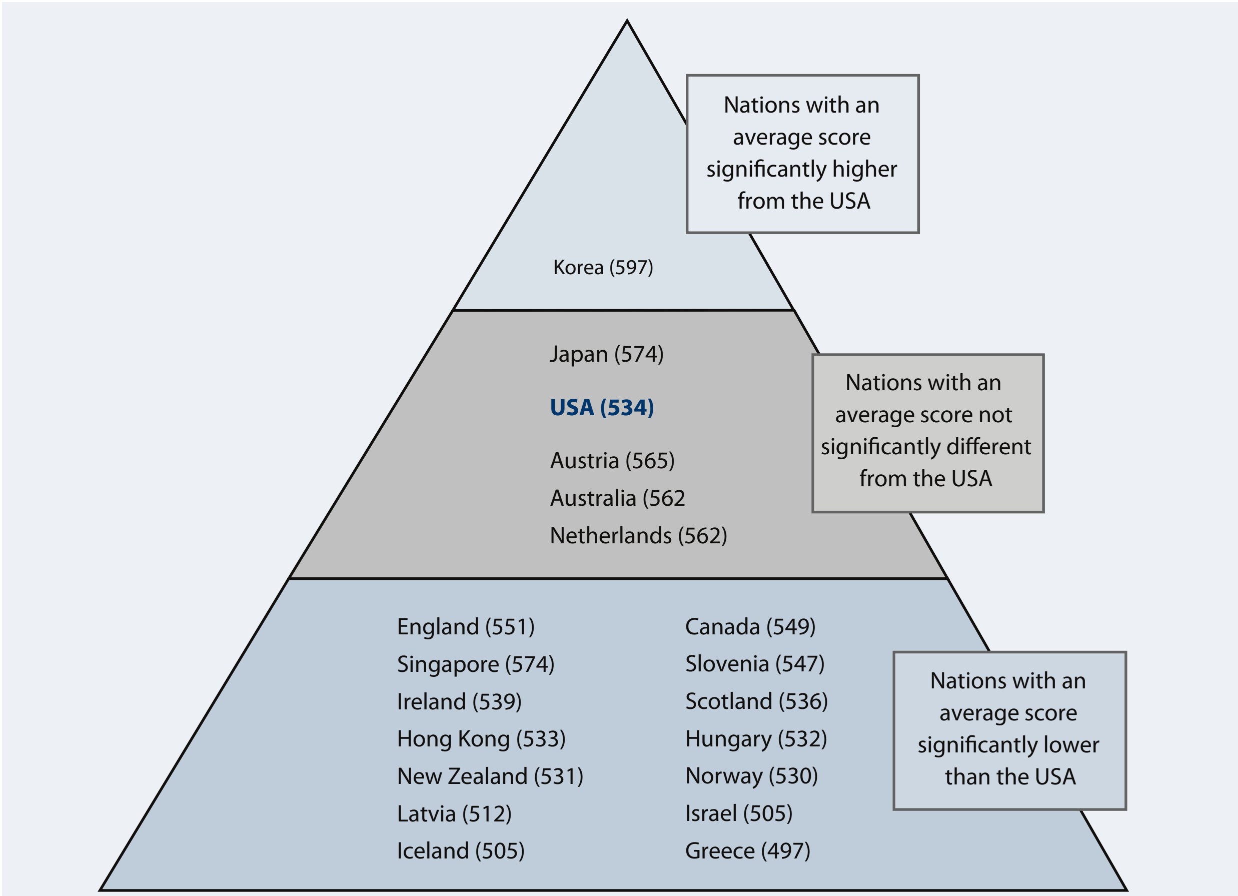
When one looks at the average scores across ethnic groups, there was no substantial change for most groups on the '96 and '00 tests. However, the score for grade 8 Native American students and grade 12 Anglo students dropped significantly from 148 to 134 and 159 to 154, respectively.

Table 5 provides a more visual indicator of how the gaps in average scores across ethnic groups for the '96 and '00 NAEP tests have remained unchanged. Mathematically speaking, these wide gaps in achievement should be interpreted with caution, of course, because most of them were not found to be statistically significant. Speaking as a Latino science educator, however, I cannot help but worry about how pervasive this pattern of student achievement has been over time (since the original NAEP in 1970) and across different tests and grade levels (see Rodriguez, 1998a). It is also a serious concern how poorly *all* students perform across various tests. In other words, only a small percentage of students performed at the *Proficient* level, with even a smaller percentage performing at the *Advanced* level (that is, 3–4% for all grade 4 and grade 8 students in '96 and '00, respectively, and between 3–2% for grade 12 students during the same years; NCES, 2002a).

Some teachers, administrators, parents and politicians continue to explain these gaps in student achievement by some kind of circular-blame game. That is, some teachers blame the parents, some parents blame the schools, some schools blame the politicians, some politicians blame the teachers, and in the meantime, researchers mainly document and keep the score in this blame game. The stereotyping of parents and teachers and the often unattached and distant approach used by researchers contribute to the misunderstanding of the differences in student

[7] The NAEP scale used to determine whether a student's score falls within the *Basic, Proficient,* and *Advanced* levels is different for each grade. For example, for grade 8 a score between 138 and 169 points falls within the *Basic* level, scores between 170 and 203 points, and scores between 204 and above, fall within the *Proficient* and *Advanced* levels, respectively. See the NAEP technical report for more details at http://nces.ed.gov.nationsreportcard

Figure 12 **Grade 4 average science scores from various countries compared to the USA— TIMMS 1995**



Source: NCES. (1997)

achievement observed here. Those who engage in a circular-blame game fail to understand that the gap in student achievement and participation in science is caused by a wide variety of factors. These factors need to be better understood and they will be explained in more detail below, but first, it would be useful to briefly review how our students' science achievement scores compare with those of students from other countries.

TIMSS Trends

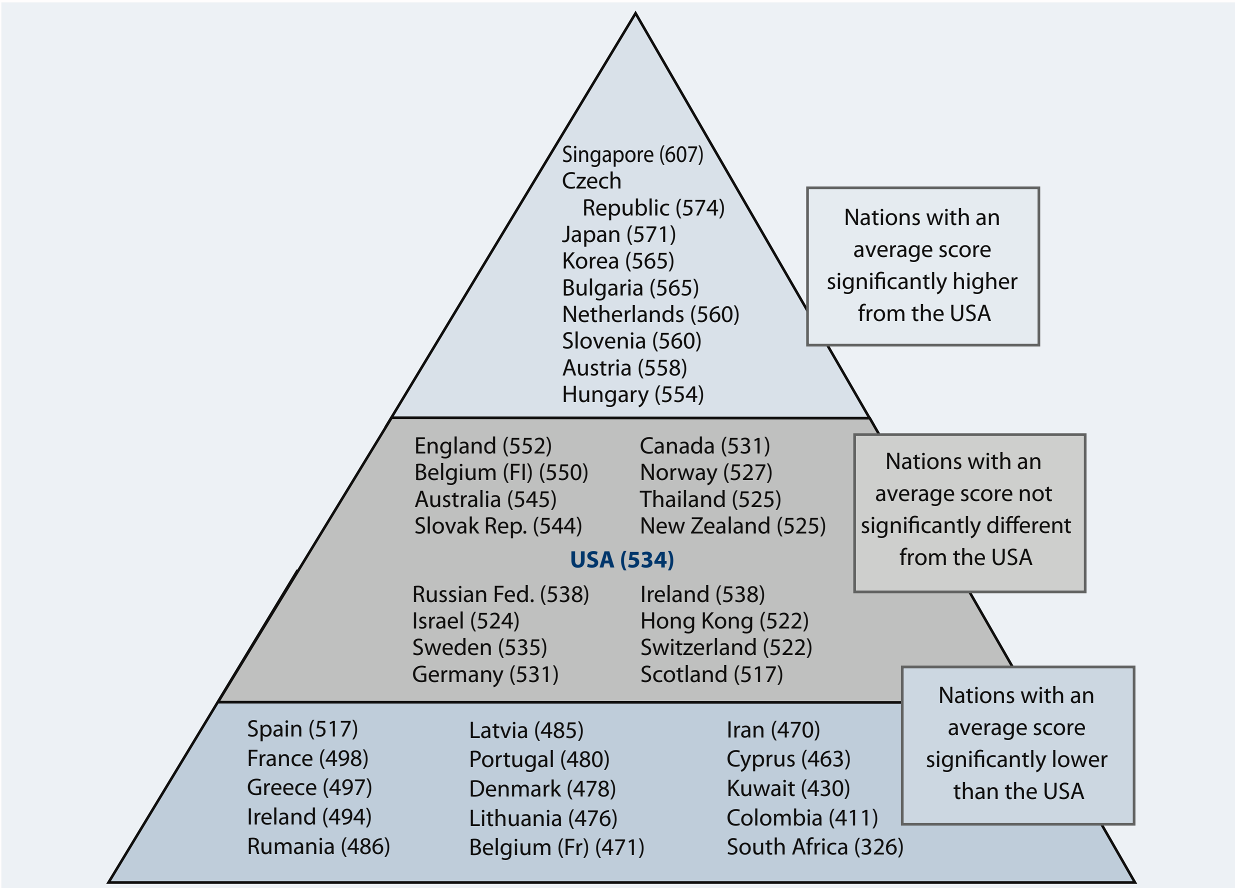
The Third International Mathematics and Science Study (TIMSS) is the largest international study ever conducted. Through TIMSS, half-a-million students from 41 countries were tested in mathematics and science at three grade levels in 1995 (NCES, 1997). Needless to say, the details of this study cannot be discussed here, but in this paper, I will focus on how U.S. grade 4 and grade 8 students performed in contrast with students from other countries on the TIMSS science portion.

Overall, U.S. students' achievement in science at both grade levels was better than that observed in mathematics, but the students' performance declined sharply for both subject areas for grades 8 and 12 (NCES, 1997, 2000a).

Starting with the grade 4 students' average score, Figure 12 illustrates that U.S. students did quite well compared to students in the same age group from the other 26 participating countries. Only Korean students scored significantly higher than U.S. students. Students from Japan, Austria, Australia, the Czech Republic and the Netherlands scored at a range not significantly different from U.S. students. On the other hand, grade 4 U.S. students' average score was higher than those attained by students from 19 other participating countries (see Figure 12, NCES, 1997).

How do our top students compare to the top students from other countries? When one takes a closer look at the achievement rate of the top 10% of students from each country, U.S. students take the lead for the first time with 16%

Figure 13 Grade 8 average science scores from various countries compared to the USA— TIMMS 1995



Source: NCES. (2000a)

of our students receiving a score within the top 10%[8] (NCES, 1997).

For the grade 8 test-component of TIMSS, 41 countries participated in the project. As mentioned above, Figure 13 indicates that U.S. students did not do as well at this grade level as students in grade 4. Our grade 8 students scored above the international mean, but were not among the nine top scoring nations (NCES, 2000a). In other words, the U.S. students' average score was 534 points, whereas the international mean was 516. Figure 13 shows that students from Singapore, the Czech Republic, Japan, Korea, Bulgaria, the Netherlands, Slovenia, Austria, and Hungary all scored significantly higher than U.S. grade 8 students in that order. Fifteen other countries received scores substantially lower than the U.S.

Our top grade 8 students are well represented among the top 10% of students from other participating countries. However, students from Singapore show a huge lead by having over a third of their students attaining scores within the top 10%. On the other hand, only 13% of U.S. grade 8 students achieved science scores within this range (NCES, 2000a).

U.S. students' performance is worse at the high school levels for both mathematics and science. This will not be discussed here, but it is enough to mention that grade 12 U.S. students performed close to the international average for mathematics, and below average for advanced mathematics. In physics, U.S. students received the lowest score of any other nation participating in the study (NCES, 2002b; Schmit, McKnight, Cogan, Jakwerth, Houang, 1999).

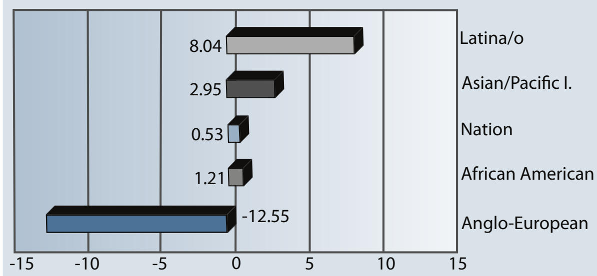
[8] Korea had 17% of their students scoring at the top 10%, but there was no statistical significance between Korean and U.S. students for this category.

Limitations and other considerations about these studies

Caution should be followed when interpreting the original NAEP scores for Latino/a students. NAEP results are less reliable for Latinos due to the confusion some individuals face when trying to identify Latino/a children (Grissmer, 1996). That is, Latinos/as could be of any shade of skin color and/or could have any range of proficiency in English. In fact, it was not until 1977 (seven years after the first NAEP study) that the category of "Hispanics" was created to include all Latino/a students.

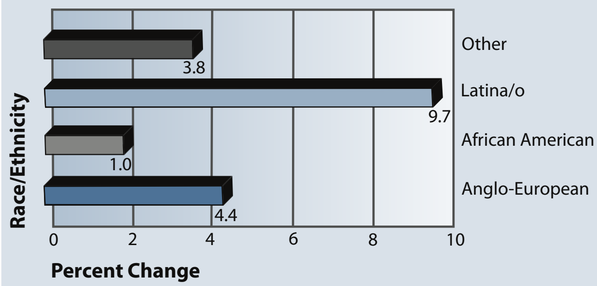
Findings from NELS follow-up studies no doubt produced a great deal of valuable information on the experiences of middle-schoolers as they progress through school and through college. However, the same problems related to identifying Latino/a students mentioned above for NAEP also applies to NELS. In addition, one of the drawbacks of longitudinal studies such as NELS is that it provides a less reliable assessment of students' cognitive performance due to the short length of time allocated for the science test (Rock, & Pollack, 1995). That is, NELS allows only 20 minutes for students to answer the 25 multiple-choice question section, the original NAEP science component has 63 multiple-choice questions at age nine, 83 multiple-choice questions at age 13, and 82 multiple-choice questions at age 17 (Mullis et al, 1994). The revised NAEP and TIMSS studies were better assessment tools since, in addition to multiple-choice questions, they included a set of constructed responses. Furthermore, students taking either one of these tests were expected to write short and extended constructed responses, thus allowing for a more meaningful measure of students' cognitive growth. However, it is not clear what kind of assistance (if any) second language learners and students with disabilities received while taking these tests. This is particularly important when one considers the short amount of time given to do these extensive tests. The assessment time for the revised NAEP was 40 or 60 minutes for fourth-grade students,

Figure 14 Percent change of the U.S. population based on ethnicity from 1970–2000



Source: U.S. Census Bureau, www.census.gov

Figure 15 Percent change in public elementary and secondary school enrollment based on ethnicity from 1976 to 1999



Source: www.nces.gov. (2002)

and 60 or 90 minutes for eighth- and twelfth-grade students, with the longer time corresponding to students that performed a hands-on task. The assessment time given to students participating in the TIMSS study was very similar.

Summary

The general pattern in academic performance by gender, socioeconomic status and ethnicity observed so far in NELS is congruent with that observed in the NAEP and TIMSS tests. This is so even though there are marked differences among these assessment tools. Another thing that these tests have in common and that represents a significant drawback in interpreting the results is that they do not provide a breakdown of the achievement scores by gender within ethnic groups. Therefore, it is not possible to determine, for example, whether the achievement level of African American girls is different from that of African American boys, or different from that of females from other ethnic groups. Similarly, it is not possible to determine whether Mexican boys or girls are achieving at a higher rate than Puerto Ricans or than students from other Latino groups. It is essential that more detailed information be gathered and made readily available in order to effectively assess student achievement in terms of equity. This information is especially imperative when we consider how rapidly the U.S. population is changing. For instance, Figure 14 illustrates how the distribution of the U.S. population has changed in the last decades (U.S. Census Bureau, 2000). As it can be observed, Latinos/as are now the second largest ethnic group in the U.S. (about seven years earlier than previously predicted, Day, 1993). Figure 15 shows the obvious impact on student enrollment when Latinas/os are the fastest-growing ethnic group in the country. Furthermore, within the broad ethnic category of Latina/o, Mexicans constitute the largest ethnic group, followed by other Latinos (peoples from various Latin American countries), and Puerto Ricans being the third-largest Latino group.

Another important aspect to keep in mind regarding these national and international tests is that even the students who are doing well are not doing that well. Only a small percentage of students scored at the proficient level and even less at the advanced equivalent levels for the original and revised NAEP, as well as for the NELS. Similarly, if we were to use the same grading scale that probably most U.S. teachers use to assign grades to students who participated in the TIMSS, then even the U.S. students who did above the international average would have received the equivalent of an "F" for both grade 4 (mean score = 57%) and grade 8 (mean score = 53.4%). This is estimated based on the fact that the maximum possible score for the TIMSS was 1,000 points[9] (see Figures 12 and 13). Using the same criterion, Korean students—who achieved the top TIMSS score for grade 4—would have received a "C" average (60%) by U.S. teachers' traditional scoring standards, and Singapore—the top grade 8 scoring country—would have received the same grade (61%).

In any case, the consistent trends in student achievement over time and across different kinds of tests at various grade levels shown here point to the need to move beyond "gap gazing"[10] and begin to pay more attention to the many factors that prevent teachers from doing their best job and that prevent students from showing what they can really do.

In the next section, some of these key factors that contribute to sustaining the current gap in academic achievement and participation between Anglo and traditionally underserved students will be explored.

[9] The maximum number of points for the grade 4 exam was 1000 points; however, I was unable to find for certain whether the grade 8 exam has the same maximum number of points. Based on the average scores shown in Fig. 13, this seems to be a safe assumption.

[10] Bill Clune (1996) personal communication.

Factors Affecting the Trends in Student Achievement and Participation:

Has Anything Changed?

In 1988, the Mid-Atlantic Equity Center—with funding from the U.S. Department of Education—published the monograph, *Mathematics and Science: Critical Filters for the Future* by DeAnna Banks Beane. It is striking to see that the same issues affecting student achievement that Beane addressed in her monograph still play the same roles today. Rather than replicating Beane's work, in the following sections, I provide an update. This update on the factors that affect student achievement in science is organized into three major areas: student-related factors, teacher-related factors, and institution-related factors. Even though all of these factors are closely intertwined and usually have a cumulative effect on students' lives, they will be discussed separately to better understand their individual—yet significant—impact.

Student-Related Factors

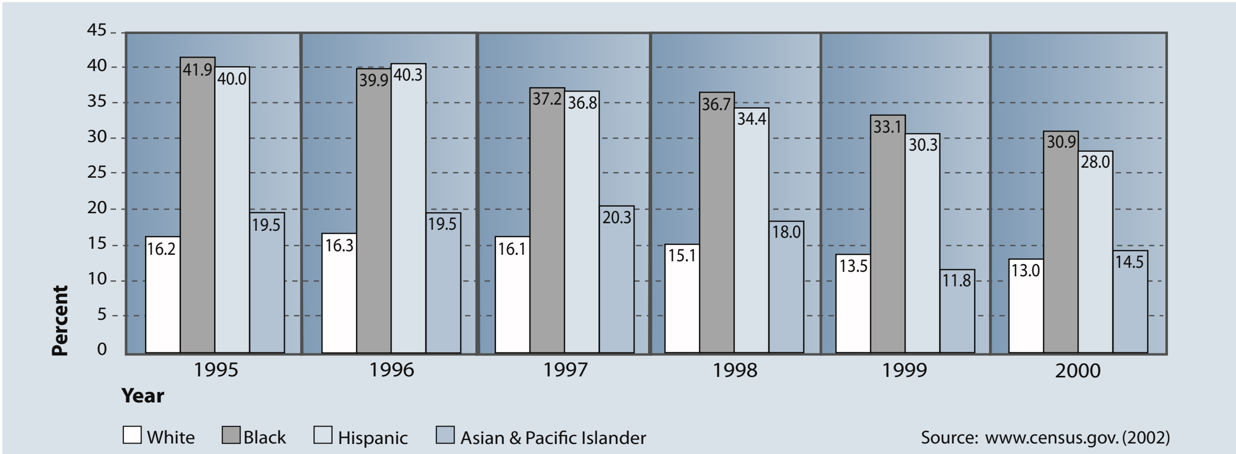
1. Students' attitudes toward science

The pattern in students' attitudes toward science reported in the monograph by Beane (1988) mentioned above has not changed. In two recently released reports, *Land of Plenty: Diversity as America's Competitive Edge in Science, Engineering, and Technology* prepared by the Commission on the Advancement of Women and Minorities in Science, Engineering and Technology Development (the Mendoza Commission, 2000) and *Trends in Educational Equity of Girls and Women* written by Bae, Choy, Geddes, Sabble and Snyder (2000), it is stated that at the elementary level—regardless of gender and ethnicity—students seem to like science and feel confident in the subject. For instance, in grade 4, about an equal percentage of boys (68%) and girls (66%) responded positively to the statements, "I like science," and "I'm good at science." However, by grade 8—for both mathematics and science—the percentages of females who believe they are good at these subjects dropped significantly compared to the percentages of male students (Bae et al, 2000). In addition, according to the Mendoza Commission "by grade 8, twice as many boys as girls (independent of race/ethnicity) show an interest in SET (science, engineering or technology) careers" (p. 16). The Mendoza Commission also states that even though girls demonstrate abilities to do well in SET, their interest and participation in mathematics and science activities go down. This is an interesting phenomenon because while female and other traditionally underrepresented students' enrollment in SET courses have steadily increased (Suter, 1996) this same pattern is not reflected in the number of female and underrepresented students seeking college degrees in SET. In fact, in one study over three quarters of SAT-takers who were interested in pursuing engineering and computer science fields in college were males. The biological sciences continue to be the only field attracting more females than males (Mendoza Commission, 2000).

These consistent patterns suggest that a variety of factors (like the ones discussed below) play a role in discouraging female and other underrepresented students from pursuing SET-related fields despite these students' abilities and original interest in SET.

[11] The survey data included students' responses from the base-year (grade 8), first follow-up (grade 10) and second follow-up (grade 12) studies.

Figure 16 Percentage of individuals (under 18 years old) living at or below the poverty rate by ethnicity, 1995–2000



2. Family's education and socioeconomic status

In a study conducted by Horn (1998) using survey data[11] from the National Education Longitudinal Study (NELS, described above), it was found that among the most common risk factors—or increased probability that a student would fail or drop out of school—were changing schools two or more times (27%) and being in the lowest socioeconomic quartile (18%). Horn (1998) also found that when low socioeconomic status (SES) is considered, students at moderate or high risk of dropping out were most probably Latina/o or African American. The researchers add that African American students were "about twice as likely to be at high risk (22%) than they were at low risk (10%)" (p. 12).

Parents' education has always been closely associated with SES, so unfortunately it is not surprising that 58% of the students found at high risk of dropping out of school had parents who have achieved no more than a high school education (Horn, 1998). When one takes a closer look at the poverty rate among children under 18 years in the United States (see Figure 16), it is easy to understand how some students from diverse backgrounds may be caught in a spiraling cycle of poverty. Figure 16 shows that even though the poverty rate has decreased for Latinas/os and African Americans, there are still disproportionate differences when the population demographics are considered. Furthermore, a report by the Census Bureau, *Poverty in the U.S.* (2000b) indicates that children (18 and younger) make up 38% of the poor in the U.S., yet children represent 26% of the total population.

One interesting aspect of the Horn (1998) study is that they investigated the factors associated with increasing the odds that students—commonly identified as at risk—would stay in school and go on to college. They found that students whose parents frequently discussed school-related matters with them had more than double the odds of enrolling in a four-year college. This points to the need to encourage more parents—regardless of their SES and/or education level—to talk to their children about school and career goals. Schools can play an important role in helping parents become more involved by facilitating parent-to-student and parent-to-teacher communication workshops. Furthermore, schools (and local governments) can also play a key role in interrupting the cycle of poverty affecting the families of students from diverse cultural backgrounds and low SES by facilitating information (in various languages) on adult education programs. When one considers, for example, that only one out every two students in Latin America completes the sixth grade and only one out every three enrolls in high school, it is not difficult to appreciate that the children of some migrant workers or of new immigrants to

[12] Other examples of the desperate need for educational reform in Latin America are the facts that in Chile only 50% of the students finished high school in 1998, and in Mexico the graduation rate was even worse with only 30% completing high school during the same year (CIEECE, 2001).

the United States may have special educational needs that go beyond acquiring English as a second language[12] (Comision Internacional sobre Educacion, Equidad y Competitividad Economica en America y El Caribe, CIEECE, 1998, 2001). If we add to this equation the increasing number of free trade agreements with various countries (that allow more fluid movement of workers across international borders), we must also pay close attention to the economic, social and moral advantages of having a better-educated, better-paid and productive work force.

3. Peer and sibling support

The impact of peers and siblings on student achievement is usually described negatively in the literature and in the media (e.g., gang activity, school violence, drug abuse, and so on). However, using the same survey data from the NELS study mentioned above, Horn (1998) found that peers and siblings can also play a major positive role on whether at risk students stay in school and go on to college. For instance, Horn (1998) explained that at-risk students whose peers expressed a strong interest in learning activities had 70% higher odds of pursuing a higher education at four-year colleges and almost two and half times the odds of enrolling in any postsecondary institution. As expected, students at risk who reported that their friends planned to attend college had six times higher odds of doing the same.

These findings are congruent with those from a study conducted by Rodriguez (2002) in an economically impoverished, rural high school in the U.S. Southwest borderlands. Most of the grade 10 students interviewed were Latina/o and most of them and their peers intended to go to college. The students, however, seemed to have little idea of what kind of academic requirements they needed to pursue their respective careers. In addition, some of them were not clear on what their potential careers may entail. One student, for example, who wished to become an electrical engineer, believed that repairing TV sets is what electrical engineers do.

It seems obvious then that if schools strive to create a community of learners in which a culture of peer collaboration and support is encouraged and highly valued, the odds are that more students usually identified as at risk may go on to college, and thus break away from the entrapments of the cycle of poverty into which they may have been born. Similarly, ensuring that each child has a career plan by the end of grade 10—designed in collaboration with the school counselor and the students' parents—may increase the chances that each student is taking the courses necessary not only to be successful but to stay interested in school.

4. Language

While we live in an increasingly smaller planet where communications technology and a global economy continue to bring us closer together, speaking a second language is still perceived as a deficiency in the United States. Bilingual education programs—wherever they may exist—often look more like remedial English programs, and they are constantly threatened by cutbacks, teacher shortages, and/or English-only supporters (Secada, Chavez, Garcia, Muñoz, Oakes, Santiago, & Slavin, 1998). In contrast, children attending European schools are expected to become fluent in more than one language as part of a well-rounded education.

This is the kind of inclusive education needed in our country, especially when, according to the U.S. Census (2000), it is estimated that 45 million people speak a language other than English at home. Even though this an unavoidable reality—and something that should really be perceived as a positive feature of a democratic and developed country—most teachers are not being prepared to work with an increasingly linguistic and culturally diverse society. This is the topic of the next section.

Teacher-Related Factors:

1. Teachers' professional preparation

It is a well-documented fact that most new teacher graduates do not feel adequately prepared to teach science and/or mathematics, especially at the elementary and middle school levels (Weiss, Banilower, McMahon, & Smith, 2001; NCTAF, 1996). In a more recent survey study with almost 6,000 K–12 teachers from 1,200 schools across the U.S., Weis et al (2001) found that "while roughly 75% of elementary teachers feel very qualified to teach reading/language arts, approximately 60% feel very qualified to teach mathematics and about 25% feel very qualified to teach science" (p. 30). The obvious impact of this reality on student achievement and participation in science gets worse when we consider that "in schools with the highest minority enrollments, students have less than a 50% chance of getting a science or mathematics teacher who holds a license and a degree in the field he or she teaches" (p. 16, NCTAF, 1996).

Given that these are well-known facts and that common-sense recommendations have been put forward to address these issues (such as higher salaries, more opportunities to major in more than one-subject area, and so on, NCTAF, 1996), I will present below other important aspects of teacher professional development that are seldom discussed in the reform literature. These aspects have to do with teacher resistance to learning to teach for diversityand understanding.

For instance, consider the following excerpt from an essay written by one of my elementary science methods students in response to assigned readings for the class:

> I also believe that it is important for educators and teachers, as well as everyone, to embrace diversity and multiculturalism. A few weeks ago, I heard some of my peers discussing multiculturalism, and they were saying that they thought it was so "annoying" that the education department promoted multiculturalism, and that it was stupid, and when they wrote papers they wrote what their professors wanted to hear, not what they really felt. I thought it was sad, and a little scary, that these people are our future teachers and they thought the "whole diversity and multicultural thing was annoying and stupid." It made me think that there are plenty of educators out there who also think like this, and there are even more children who will become the students of these teachers who will suffer because of their ignorance.

These comments are not uncommon among some of the pre- and in-service teachers with whom I have worked in my classes and/or in research projects. These types of comments are particularly disturbing when one considers that most of the pre-service teachers in our teacher education program will be seeking jobs in an area of the U.S. Southwest where over 80% of the student population is Latina/o. On the positive side, it has been my experience that most of the pre- and in-service teachers with whom I have worked have become more open to teaching for diversity and understanding after they have had many opportunities to collaboratively explore more student-centered, socially relevant, and culturally responsive ways of teaching (Rodriguez, 1998b, 2002). Nevertheless, there is always a group of individuals that remain entrenched in their beliefs and resist learning to teach for diversity. As a matter of fact, the learning to teach and multicultural education literature is flooded with articles describing pre-service teachers' resistance to learning to teach for diversity (Chavez & O'Donnell, 1998; Grant, 1999; Rodriguez, 1998b).

Elsewhere, I argued that teachers' resistance can be better described and understood by differentiating between their *resistance to pedagogical change* and their *resistance to ideological change* (Rodriguez, 2001a). Resistance to pedagogical change is defined as the resistance to changing one's perceptions of what constitutes being an effective teacher in today's schools. It is not surprising for beginning teachers to resist teaching for understanding (or resisting to teach in more inquiry-based, socially relevant and inclusive ways) when they have already been exposed to an "apprenticeship of teaching" by virtue of 15 or so years of being in school before entering a teacher education program (Lortie, 1975). In other words, educators like myself have typically only 15 weeks in a science methods class to engage pre-service teachers—who are most likely middle-class, female and Anglo—with more effective, gender-inclusive, and multicultural ways of teaching science that could help their students learn for understanding. Thus, it is not surprising to encounter resistance to these pedagogical approaches when they differ so much from the transmissive and behaviorist approaches they have encountered for 15 or so years of schooling—and that have worked well enough for them to be admitted into teacher education programs. This cycle continues to perpetuate itself as many teacher graduates often feel that they cannot apply what they learned in teaching education programs because of curriculum and standardized tests constraints, or because they fear losing control of their students' behavior through student-centered

pedagogical approaches (Rodriguez & Kitchen, in press). A recent report on mathematics and science teaching makes evident that in spite of all of the calls for educational reform, most teachers simply continue to teach the way they were taught (Weiss, Pasley, Smith, Banilower, & Heck, 2003). For instance, Weiss and her colleagues at Horizon Research found that after observing 364 lessons taught by K–12 teachers from various parts of the United States fewer than 1 in 5 lessons were intellectually rigorous. Furthermore, 66% of the teachers observed used inadequate or low level questioning strategies. Similarly, in 66% of the classrooms observed, students were engaged in what Weiss and her colleagues called "inadequate sense-making"; that is, teachers not helping students make relevant connections with the key concepts being covered in the lesson. In only 16% of the classrooms, the research team found teachers actively engaging students in more meaningful understanding of the subject matter and in high-level questioning. On the positive side, the researchers also found that most teachers appeared confident and provided accurate and significant science and mathematics content.

The findings reported by Weiss et al (2003) make clear that educational reform must be driven by more than the politics of accountability; that is, the assumption that by only requiring more standardized tests for students and/or for teachers to obtain certification, student learning or teaching practice will improve. This assumption is akin to requiring firefighters to pass standardized tests before certification, and then expecting them to put out fires without water and other essential equipment.

As teacher educators, we constantly face the challenges of helping experienced and beginning teachers explore and resolve the contradictions between what the National Science Education Standards and other reform documents suggest and how many teachers continue to teach and/or believe that they are expected to teach to meet standardized tests requirements. Another way to help address this situation besides providing funding that matches the expectations for educational reform is establishing more support and collaboration among university faculty outside of colleges of education. In this way, university faculty across science and mathematics disciplines could be more in tune with the recommendations being put forward by various national organizations such as the National Research Council (*National Science Education Standards*), the American Association for the Advancement of Science (*Science for All Americans: Project 2061*), and many others. For example, new professional development and research grants programs could facilitate more meaningful collaborations among education faculty, schoolteachers and administrators, and science faculty. In this fashion, beginning teachers could be provided with effective teaching models in multiple contexts. That is, student teachers will not only see culturally inclusive and student-centered teaching modeled in their methods courses, but also in their regular college-level science courses, as well as during their student teaching field experience.

The other type of resistance commonly encountered among pre- and in-service teachers is *resistance to ideological change*. This is defined as the resistance to changing one's beliefs and values systems. For example, some pre- and in-service teachers believe in a kind of "rugged individualism" that has worked well for them and their families as members of the predominant culture. Through this ideological lens, they believe that if students from diverse backgrounds spoke English only, "worked hard enough," or had "caring parents," they would do well in school

(Rodriguez, 1998b). Individuals who adhere to these beliefs often get very defensive when asked to reflect about their inherent positions of privilege as members of the predominant culture or by virtue of their SES (Sleeter, 1994). In fact, these individuals often dismiss research evidence on trends in student achievement, tracking practices, gender discrimination, racism and other social ailments afflicting our schools by claiming that these are "issues of the past." In the last two decades, many articles and books have been written describing pre- and in-service teachers' resistance to ideological change (Alhquist, 1991; Cochran-Smith, 1991; 1995; McInstosh, 1989; Tatum, 1992, Rodriguez, 1998b). What is lacking in the teacher education literature is more practical suggestions for how to assist experienced and beginning teachers in becoming more willing and able to teach for diversity.[13]

In short, by first acknowledging and understanding teacher resistance to ideological and pedagogical change, teacher educators and administrators may be able to provide more effective professional development experiences. Furthermore, if we acknowledge that resistance to change is an unavoidable step toward meaningful professional and personal growth, we may feel more encouraged by the fact that those resistant to ideological and/or pedagogical change are at least becoming more intellectually engaged and aware of the kind of teachers they wish to become in a pluralist society. One obvious point of departure for this personal and professional journey of becoming and understanding what it means to be "a good teacher" is to reflect on the fact that 84.3% of the teaching force in the U.S. is Anglo, female and middle class (NCES, 2003). Whereas, as indicated in Figure 15, the faces and cultural backgrounds of many of the students these teachers will most likely encounter in their classrooms will not mirror theirs.

2. Teachers' expectations & stereotyping

Teachers' lower expectations of culturally and linguistically diverse students have been long associated with poor student achievement (Secada et al, 1998; Peng, & Hill, 1995). It follows then that teachers' lack of experience with students from cultures and SES levels different than their own end up producing stereotypes, which drive a wider wedge between teachers and students and teachers and parents. One of the most common stereotypes is the *Pobrecito Syndrome*. This stereotype refers to the tendency of some school officials to have lower expectations of Latina/o children because they feel sorry for these children's SES, family structure, English language skills, and/or cultural backgrounds.

One way to assist some teachers to move away from these damaging stereotypes—besides encouraging them to expand their first-hand experiences with culturally diverse individuals—is to expose them to research on this topic. One key source is the study conducted by Patricia Gandara and reported in her book, *Over the Ivy Walls: The Educational Mobility of Low-Income Chicanos* (1996). As part of this project, Gandara conducted in-depth interviews with 50 Latinas and Latinos who had two major things in common. They all completed the highest post-secondary degrees (Ph.D., M.D. and J.D.), and they all came from the *barrios* (or economically impoverished Latina/o neighborhoods). These individuals explain in detail their struggles to be taken seriously by teachers and other school officials, and how their parents made all sorts of sacrifices to assist them in pursuing their career goals. As more teachers become aware of their own stereotypes and learn more about the struggles of diverse students and their parents to access equal opportunities to learn, more opportunities for collaboration and mutual success are possible.

Institution-Related Factors

1. Tracking

Tracking is to the schooling of diverse students what cancer is to a healthy body. This pervasive institutional practice continues to dominate how diverse students are "sorted out" in public schools, and it continues to deprive students of equal opportunities to learn.[14] Although a

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[13] This is the subject of a book I edited with Rick Kitchen (Rodriguez & Kitchen in press). This book brings together science and mathematics teacher educators to describe their pedagogical strategies for helping teachers learn to teach for diversity and understanding.

[14] Standardized testing is another discriminatory institutional practice closely associated with tracking. Standardized tests are usually normed using student populations that are different from the culturally and economically diverse student

large body of research in the last decade has clearly demonstrated how tracking adds to the multiplicative effect of the various inequalities to which diverse students are exposed in schools, this research continues to be ignored (Oakes, Ormseth, & Campbell, 1990; Peng, & Hill, 1995; Tierney, 1997). Furthermore, tracking practices contradict the notion of "science for all" being promoted by key reform documents such as the National Science Education Standards (NRC, 1996) and Project 2061 of the American Association for the Advancement of Science (AAAS, 1989) to name a few.

An example of how tracking adds to the social disadvantages some diverse students already face can be found in Peng and Hill's (1995) study. These researchers used student data from the NELS base year (8th-graders) and the first follow-up test (10th-graders) to explore the impact of specific factors on student achievement. These researchers looked at the following factors: "educational activities at home, course work in school, teacher qualification, school environment, and student learning behavior" (p. v). They found that each one of these factors has an impact on student achievement, but when these factors were considered jointly, they could account for as much as 45% of the gap in scores between diverse students and Anglo and Asian students. Peng and Hill (1995) also found that a larger percentage of diverse students were placed in low achievement groups and low-track high school programs. These researchers add that "consequently, [diverse students] have received less rigorous academic training and have failed to obtain enough preparation, competence, or motivation to take more higher level courses that prepare them for science and mathematics-related fields" (p. vi).

The *Land of Plenty* report prepared by the Mendoza Commission (2000) and the Hispanic Drop Out Report (Secada et al, 1998) are also two of many major national reports and/or studies condemning tracking as a discriminatory practice that must be eliminated. What is the alternative to tracking? Placing students in culturally and ability diverse groups is one alternative. However, this strategy cannot be implemented in overcrowded classrooms and in schools with limited resources and support for teachers. This is another institutional factor that plays a key role on student achievement, and it is discussed next.

2. Class size and access to equipment and materials

According to the National Commission on Teaching and America's Future report (NCTAF, 1996), one of the key factors influencing the ability of teachers to teach for understanding is class size. In fact, the Commission proposes a radical plan for school restructuring that moves beyond the traditional industrial model that dominates most schools in the U.S. For example, the Commission suggests that instead of having only 24 classroom teachers, 26 other staff, an average class size of 25 students, and teacher planning for about 3.75 hours/week serving 600 students, we should restructure the way we serve the same number of students by increasing the number of teachers to 43 (full-time employees, FTE); reduce the number of other staff to 7 (FTE), reduce the class size to 16 students, and increase the number of teacher planning time to at least 10 hours/week. In the redesigned elementary school, three teams of 7 teachers each would work closely with about 100 students each at the lower grade levels. To facilitate opportunities for professional development and the use of instructional technologies, a lead teacher and media/computer specialist would devote half of her/his time coordinating the curriculum and visiting the team teachers' classrooms. The other half of this teacher's time would be devoted to teaching so that the other teachers in the team could visit each other's classrooms. This same model is repeated at the upper elementary grades.

The Commission argues that this new model affords teachers a more collegial environment with many opportunities for professional development and collaboration. In addition, the new team model approach with smaller classes allows richer teacher-to-student and student-to-student interactions and better access to equipment and materials.

Interestingly, the Weiss et al (2001) teacher survey mentioned above indicates that only about 7% see class size as a factor influencing instruction. Most teachers involved in this survey see the lack of appropriate resources and equipment as serious issues influencing the teaching of science and mathematics. In fact, "inadequate funds for purchasing equipment and supplies was labeled as a serious problem by 25-35% of the respondents [teaching at the elementary, middle and high school levels], inadequate facilities by 20-28%, and lack of materials for individualized instruction by 16-27%" (p. 101). These findings seem to indicate that—if given a choice—most science and mathematics teachers would rather have the proper equipment and materials to carry out their jobs well than to have smaller classes and no access to equipment and materials. Ideally, by heeding the National Commission on Teaching and America's Future's (1996) restructuring recommendations, teachers could have both—smaller classes and access to equipment and materials.

3. Teachers' working environment

Teachers who leave the profession cite "dissatisfaction" with their working environment as one of the main reasons why they quit (Glenn Commission, 2000). This is a fact more commonly found among mathematics and science teachers (40%) than teachers who leave from other curriculum areas (29%). In addition, about 66% of science and mathematics teachers who leave teaching state that "poor salaries" is the number one reason they are dissatisfied with their jobs. It is no wonder that so many teachers leave the profession considering that teaching is one of the lowest-paying professions after completing at least four years of college, coupled with an often high student-to-teacher ratio and the lack of access to equipment and materials. However, if there is one thing the reports cited so far have in common it is that in order to recruit and retain more than the two million teachers needed in the next decade, the teachers' working environment must be dramatically improved. At the center of this improvement is providing teachers with increased salaries and more meaningful opportunities for collaboration and professional development. Weiss et al (2001) found that most of the approximately 6,000 teachers who participated in their survey stated that they did not have time to plan and/or discuss issues related to the teaching of science and mathematics. Furthermore, there seems to be a mismatch between teachers' professional needs and the focus of professional development opportunities offered. In other words, Weiss et al (2001) found that "only a third or fewer of the respondents perceived a strong emphasis in an area where they indicated a strong need for professional development" (p. 45).

4. New policies: The No Child Left Behind Act

In addition to the factors mentioned above, one key institutional factor that influences what and how teachers teach is the ratification of new education acts. While these nation-wide policies tend to outline a long list of well-intended objectives, many of these objectives have little hope of ever being met because they lack the necessary financial support and insights generated from solid research on teaching and learning. Take for example, President Clinton's Educate America Act, Goals 2000. According to this law:

(A) By the year 2000, the high school graduation rate will increase to at least 90%.

(B) The objectives for this goal are that

(i) the nation must dramatically reduce its school dropout rate, and 75% of the students who do drop out will successfully complete a high school degree or its equivalent; and

(ii) the gap in high school graduation rates between American students from minority backgrounds and their non-minority counterparts will be eliminated (Section 102, School Completion,).

By the year 2000, United States students will be first in the world in mathematics and science achievement (Section 102.5.A, Mathematics and Science).

As it was already shown in the previous section on student achievement, we are still far off from meeting these goals. Now, President Bush's *No Child Left Behind Act* (NCLB, U. S. Department of Education, 2001) also outlines a well-intended set of policies without the financial and educational research backing to make them possible. Nevertheless, the NCLB Act has generated a great deal of attention because—unlike the Goals 2000 Act—it comes with an accountability/punitive component if schools, administrators, and teachers do not meet the prescribed objectives by a set timeline.

The NCLB raises many other interesting issues worthy of further analysis, but only some of the aspects of the NCLB Act relevant to this monograph are discussed here. These aspects are:

a. *Increased Accountability*: States must develop rigorous content standards and implement statewide assessments to measure students' annual academic growth in grades 3 through 8 reading and mathematics. Students' performance must be broken down according to the students' ethnicity, socioeconomic status, English language proficiency, and disability. Science content standards and corresponding assessments should be developed next.

b. *Set Timelines to Demonstrate Performance*: According to the NCLB Act, by the end of 2013-2014, twelve years after being passed, states are expected to have **all** of their students performing at the proficient or above levels on statewide, standard-based assessments.

c. *Consequences for Failure to Meet Standards:* Schools that fail to demonstrate adequate yearly progress (AYP) and that do not move toward closing the gap in student achievement across various ethnic groups will be placed in the "identified for improvement" category. This means that schools placed in this category must provide students with alternative opportunities to succeed such as attending a different school within the district (and pay for the student's transportation if needed). The NCLB Act also states that schools that continue to fail to meet the standards will be allowed to use up to 20% of their Title I funds to provide school choice and/or supplemental educational services to qualified students. The bottom line is that schools that fail to make adequate yearly progress for five years will be re-organized and put under a new improvement plan.

No doubt several aspects of the NCLB Act are needed and welcome, especially when it comes to ensuring that traditionally underserved students have opportunities to experience not only equal access to but also success in education. So, if the NCLB Act is a national policy that directly addresses issues of school accountability and the gap in student achievement, why is it being widely criticized?

Some researchers argue that the NCLB law does not take into account the complexity of providing appropriate resources to school districts with high student achievement gaps. For example, Rechovsky and Imazeki (2003) developed an educational cost function using funding data from elementary and secondary school districts in Texas. They then estimated a cost index that could be used to ensure that school districts receive the appropriate financial support they required. Rechovsky and Imazeki (2003) also state that "present evidence suggesting that measuring student performance, setting performance standards, and threatening to sanction schools that fail to meet those standards are unlikely to close the achievement gaps unless accompanied by a restructuring of the financing of public education" (p. 264).

Linn, Baker, and Betebenner (2002) seem to agree, and in a clever and timely analysis of NAEP and statewide student achievement tests, Linn and his colleagues (2002) provide compelling arguments for rethinking the accountability components of the NCLB law. They state that “the challenges posed by the NCLB law are many; unless considerable flexibility is allowed in the interpretation of some aspects of the accountability components of the law, it seems likely that many more schools will be placed in the improvement category than can be provided with effective assistance” (p. 4).

To elaborate their position, Linn et al, (2002) start by showing the trends in the percentage of students who met state standards tests in five different states from 1998 to 2001. They found that there was a great deal of variability in student performance in reading and mathematics grade 8 tests, as well as different kinds of interpretation of what some states may perceive as “passing” state assessments and being “proficient.” In addition, Linn and his associates used straight-line projections to explore what it would take by some states to meet the NCLB’s requirement of having all students achieving at the proficiency level on state assessments by 2012. They found that states that already have high test scores may need to maintain a 1% per year increase in student achievement; whereas the states with the lowest achieving scores will have to maintain more than 5% increase in student achievement every year for 12 years.

This already formidable task is complicated by the fact that few states currently show students scoring at the proficient level in the NAEP (a national test discussed earlier and in which, according to a new provision in the NCLB law, every state must now participate every two years). By looking at the change in percentage of students who scored at the proficient and above levels on NAEP from year to year, Linn et al, (2002) illustrated how only 3 states showed gains of one point or more in grade 4 reading scores, 15 states showed gains in the grade 4 mathematics test, and 18 states showed gains in grade 8 mathematics

test. The number of states that participated in the NAEP ranged from 29 to 34 depending on the grade level and curriculum area. Again, this indicates that some states may have a lot more to put in place and may require more focused financial and professional development/administrative support than others to be able to meet the requirements of the NCLB law by 2012.

Linn and his associates (2002) also propose several suggestions to enhance the flexibility of the NCLB law in terms of school accountability. Two key suggestions are to use the state results on NAEP as the standard indicator of adequate yearly progress instead of the state-based assessments. By having one national and accepted common assessment tool, the effects produced by the existing variability across state assessment instruments and standards would be eliminated. The second suggestion is to use the basic level on NAEP as the minimum standard for students, instead of using the more ambitious proficiency level. As it was shown earlier, given that so few students score at the proficiency level across ethnic groups, and given that requirements to achieve this level may be set too high to be realistic, it may be practical to rethink the current expectations that all states will be ready to have all students achieve at the proficiency level. "…Having a goal that is so unobtainable no matter how hard teachers try can do more to demoralize than to motivate greater effort. Goals need to provide challenge but not be set so high that they are unachievable." (Linn et al, 2002, p. 12).

As can be observed of all of the factors that influence student achievement and participation discussed so far, and the appropriate implementation of national educational policies could play the most significant roles in helping reduce—if not eliminate—the student achievement gap across various ethnic groups. However, as the conversation continues on the pros and cons of implementing the NCLB Act, we need to keep the dialogue focused on measuring students' *learning for understanding.* After all, helping students learn for understanding is what makes schools sites for the development of critical thinking, life-long learning, and problem solving. This notion should be what drives the eradication of achievement gaps and the development of meaningful standards and assessment tools.

Summary

In the last decade, a strong base of research clearly indicates that each of the factors discussed in this monograph play a key role on whether students are successful—or even participate—in science classes. Perhaps the most important finding—and one that cannot be ignored anymore—is the cumulative impact these factors have on a student's academic life. For example, if a student is tracked in elementary school, this racist institutional practice will have ripple effects on that student's chances of being successful in high school and/or taking advanced science classes. This student's chances are reduced even more if he or she comes from a low SES, if his or her parents have lower than a high school education, and so on.

On the positive side, the student, teacher, and institutional-related factors that influence student achievement and participation in science can be addressed by improving teacher professional preparation, improving parent-school communication, and by restructuring schools in such a way that teachers have more opportunities for collaboration, higher salaries, smaller class sizes, and better access to technology and equipment. While this is not an easy task—and one that carries a high price tag—ignoring these factors will carry (and is carrying) an even higher social, economic, and moral price tag. Perhaps a revised and more realistic version of the NCLB law, based on sound educational research and responsive funding, may become the catalyst for long-lasting educational reform.

"Let us not wallow in the valley of despair"
— Dr. Martin Luther King,
Address to the Civil Right Marchers, Washington, DC, 1963.

Promising Cases of School Reform

While being complacent and allowing oneself to slide down into a pit of cynicism may be almost fashionable during these trying times of overwhelming challenges, broken promises, attacks on public education, and misguided reform efforts, we must heed Dr. King's words and not "wallow in the valley of despair."

In fact, if we stay the course and ground our commitment to work for social justice on the indissoluble belief that better opportunities to learn for all students is the key to social transformation, we shall learn to celebrate our successes—no matter how small. We shall also learn not to lose sight of our objectives—no matter how large the obstacle in our path may be obstructing the view. It seems that it is indeed this kind of attitude and determination that the following individuals have adopted to effect change in their own school contexts against the odds. What are some of the specific strategies for implementing change used (and being used) by these teachers, teacher educators and administrators? To explore the answers to this question, the following sections offer highlights from some promising initiatives, and to facilitate discussion, the sections have been organized into two broad categories. These are: projects that started with small-scale funding and projects that started with large-scale funding. It is important for the reader to note that in spite of the large differences in original funding, these initiatives had two major things in common: the unshakable commitment of all those involved to effect change and the fact that these initiatives were being implemented in economically disadvantaged and diverse school contexts. Another aspect to note is the lack of small-scale intervention studies with a focus on science education reform. The studies discussed in the first section below were selected because they were successful across curriculum areas, but it was very difficult to find promising intervention studies with a focus on science education only. (Readers are encouraged to do a bibliographical search in ERIC—a search engine of educational research studies—using the terms, "Latino" or "Hispanic" or "African American," and "science education," and "achievement." There seem to be many articles that tend to focus on student achievement "gap gazing" and fewer on interventions leading to achievement gap reduction or eradication).

Promising cases of school reform: Projects that started with small-scale funding

Deborah Meier, the author of *The Power of their Ideas: Lessons for America from a Small School in Harlem* (1995), uses a charming narrative to highlight 30-years of successes, near-misses, and areas for growth associated with her courageous and innovative work as an educator in diverse urban schools.

In 1974, and after teaching for a few years in urban schools, Meier was already what I prefer to call "a good teacher at risk" of dropping out of the profession. Just as many good students are at risk of dropping out of unresponsive schools with culturally monotonous and insipid curricula, good teachers are also "at risk" of leaving the profession due to—among the various factors mentioned above—choking bureaucracies and the lack of professional support to respond to students' needs. Luckily, a Latino superintendent of East Harlem's District 4, Anthony Alvarado, approached Meier with the vision of starting a new, alternative elementary school. This new school was to serve a mainly Latino population, with a growing African American population, in one of New York's poorest communities.

Central Park East (CPE) started with six teachers and one paraprofessional. Three of the teachers were Anglo, two were African American, and one was Latina, and all had one thing in common—they were already dissatisfied with the current school status quo and were eager to try a different, more democratic, student-centered, and community-responsive model. The success of Meier and her team's efforts can be measured in multiple ways. She states, "Of the first seven graduating classes of CPE elementary school (1977-1984), 85% received regular diplomas, and another 11% got GEDs. This compared to roughly 50% citywide" (p. 16). Meier adds that two thirds of the students who graduated from high school—prior to the opening of their own high school—had gone on to college. Due to the success of CPE's students and its philosophy of respect, community involvement, integrated hands-on and minds-on curriculum, small class sizes, and authentic forms of assessment, within ten years three other CPE schools were open—each serving 250 students. At this time, Meier and her team were challenged to expand her model to the undisputedly most resistant school level to change—the indomitable terrain of high school education. Meier explains:

> But the obstacles that block the path of reforming a high school are harder than those that face elementary schools. Bureaucratic and financial impediments are only parts of the picture, and not the most difficult ones. The biases and prejudices of the larger society have more obvious effects as youngsters come closer to the 'real thing'—being adults. The external demands of proof and evidence are far greater in high school, the rituals more fixed (curriculum, credit hours, course sequences, daily schedules), and the 'next' institution—college or workplace—even less under our influence. But even those factors were not the most important (p. 31).

Meier and her team found that in addition to the curricular and institutional rituals that perpetuate inequities in high schools, the future of other social rituals—such as sporting events and other after-school programs—heightened the skepticism of those who felt that high school could not be changed. Again, with focused determination and a "wait and see" attitude, Meier and her team navigated though many obstacles and started Central Park East Secondary (CPESS) with 80 seventh-graders in 1984. CPESS now serves 450 students grades 7 through 12. According to Meier, in 1991 CPESS had fewer than 5% of the students who enrolled in this school at grade nine drop out. The rest of the students graduated with regular diplomas, and about 90% went on to college.

At the core of CPESS schools—just as is found in the elementary schools—we find many features that are now being hailed as necessary in various reform documents (including the reports from the various commissions and/or task forces highlighted in this monograph so far). Among these features are:[15]

1. Small schools with small class sizes that promote more student-to-student and teacher-student interactions.
2. Where schools are large, the students and staff are divided into interdisciplinary houses that allow students to stay with the same teachers for more than one year.
3. Curriculum integration across various subject areas is expected and required.
4. Less is more—fewer subjects being taught allows more in depth exploration of content knowledge.
5. Academic periods are longer in high schools (Two hours preferably or at least one hour).
6. All teachers must facilitate cooperative learning.
7. Students demonstrate meaningful learning through performance assessment activities (such as portfolios, presentations, projects, and so on).
8. Students are required to engage in socially relevant schoolwork with real connections to their community and the real world of work.
9. High school homerooms are full-periods dedicated to real student advising.
10. The teaching staff in collaboration with the administration makes decisions about pedagogy, curriculum, and course scheduling.

[15] The reader is encouraged to note that these innovative features were being implemented in the mid-80s, and it is only recently that we are starting to hear about them through national reform reports.

11. Parents are involved in and informed about their children's academic growth.

These are only a few of the features that made Central Park East Schools successful over time and that no doubt took a lot of negotiating, perseverance, and strength of spirit to see to fruition.

The next project to be highlighted here is *Lessons from High-Performing Hispanic Schools: Creating Learning Communities*. In this edited book, Reyes, Scribner and Scribner (1999) document the findings from a case study of eight schools (three elementary, three middle and two high schools) that had several things in common:

1. The schools had an enrollment of over 66% Mexican Americans students.
2. The schools had well-above average scores in the statewide test (Texas Assessment of Academic Skills).
3. The schools had received national and/or statewide recognition for student achievement.

The authors of this book were not directly involved in the reform effort at these schools. Their goal was to identify the common features across these schools that had enabled them to be successful against the odds. Reyes et al (1999) selected the schools for a case study based on the above criteria, and they gathered information about these schools by conducting site visits, interviews and document analysis.

According to Reyes et al's (1999) analysis and review of the literature on "best practices," four broad themes or dimensions should guide school reform efforts to enhance diverse students' achievement. These dimensions are:

- *Action Dimension I*: Community and family involvement are essential to the development of a high-performing learning community for Hispanic students.
- *Action Dimension II*: High-performing learning communities for Hispanic students depend on leadership at all levels that supports collaborative governance that enables every student to succeed.
- *Action Dimension III*: Culturally responsive pedagogy is required for students to succeed in a high-performing community for Hispanic students.
- *Action Dimension IV*: Advocacy-oriented assessment that motivates the individual learning of the student is crucial to sustaining a high performing learning community for Hispanic students (Reyes et al, p. 192).

Reyes et al (1999) describe some specific suggestions for enacting each of these dimensions, but they are too complex to explain here in detail. Suffice it to say that the Reyes et al findings are congruent with the strategies used by Meier (1995)—discussed previously—in the establishment of the Central Park East Schools.

Another study that exemplifies the successful implementation of school reform efforts in diverse school contexts and that provides a realistic narrative of the struggles and resistance associated with effecting change is described in Paul Heckman and his associates' (1996) *The Courage to Change: Stories from Successful School Reform.* Heckman makes a unique contribution to the reform literature because his book is co-written with several of the teachers who have been at the front lines of school change for five years in their own teaching contexts.

Using funding from private foundations, Heckman set out to find a school in which teachers and the principal would be committed to change from the bottom up over an extended period of time. He found Ochoa Elementary—one of two elementary schools in the City of South Tucson, Arizona. Ochoa Elementary had a student population of 385 students, 16 full-time teachers, 5 Title 1 resource teachers, and 12 teaching assistants. This school—like many schools in the Tucson Unified School District—had a 90% Latina/o student population. About 10% of the students came from Native American cultural backgrounds, and 95% of all students were on the free or reduced lunch program. Spanish was the primary language of most students, and about 65% of the students had arrived in the U.S. within the previous three years.

Unlike other reform efforts, Heckman's approach for effecting change at Ochoa Elementary was not to provide a preconceived notion of school reform. On the contrary, the goal was to generate a grass-root reform project based on what the teachers and the principal—in collaboration with members of the community—felt was necessary to "improve dramatically the achievement of students in mathematics, science, social science, literature, the arts, reading and writing" (Heckman, p. 8). Another important precondition for teachers to participate in the project was that they needed to collaboratively work toward restructuring "schooling practices so that poor and minority students achieve well beyond elementary, and thus the drop out rate diminishes" (p. 8).

According to Heckman, three conditions are necessary to establish successful reform efforts. The first is "Advancing Further Dialog, Inquiry and Reinvention." These conditions are the same as described above in terms of establishing open and collaborative professional development relationships among teachers and the school administration. Heckman and his associates suggest that in a nurturing and responsive professional environment, teachers would feel more comfortable to take risks and learn from one another as they move toward a common goal. The second condition involves "The Political Dimensions of Educational Reinvention." Essentially, this condition acknowledges the socio-cultural contexts in which schools function, and thus teachers are encouraged to help in the creation of partnerships with business and community organizations to effect change that moves beyond the school walls. Heckman (1996) provides an example: "the project has developed a partnership between the Industrial Areas Foundation/Southwest, known as the Pima County Interfaith Council, to encourage parents and other neighborhood members to identify and seek political action to change…that is, better housing, improved community safety, and close connections between school and the families…" (p. 192).

The third condition is "Support and Connections Among Schools and Neighborhoods." This condition is similar to number 2 above, but it focuses on cross-school collaboration and networking. In 1995-1996, Heckman and his associates expanded their project to five different schools. He explains the main objective was to seek "the development of support networks for teachers, principals, parents, and district administrators in order to further enhance their understandings and commitments to the project ideas and practices discussed in this book" (p. 194).

So far, I have presented highlights from promising school reform projects that originally started with small-scale funding. These projects have been described here because they have been successful across curriculum areas, and because it is difficult to find small-scale and promising intervention studies with a focus on science only. Nevertheless, it is hoped that a better understanding of what made these projects promising could generate insights into how to implement effective science education reform in other school settings. Next, the general features of large-scale science education reform projects are described.

Promising cases of school reform: Projects that started with large-scale funding

In the early 90's, a new approach to educational reform called *systemic reform* was gaining a lot of attention. This approach involved "reforming and restructuring the entire enterprise of education, from the level of national goals to state curriculum frameworks, on to the district, the building, the classroom, and the teacher" (Sashkin & Egermeier, 1993, p. vi).

Therefore, systemic reform is a very different approach from previous reform initiatives in that it acknowledges how deeply interconnected all the driving elements of the educational enterprise really are (O'Day & Smith, 1993). In other words, systemic reform not only aims to transform the structures and process of how education is carried out, but the culture of schooling as well. To back up such high and complex goals, the NSF began the Statewide Systemic Initiative (SSI) Program in 1991. Each state that was selected for this program received $10 million over a period of five years, and some SSIs claimed to have made a positive impact on student achievement and teacher professional development in science and mathematics. For instance, Kahle, Meece and Scantlebury (2000) conducted a study with middle school science teachers in urban schools. They found that the teachers who used the standard-based pedagogical strategies promoted by the Ohio SSI had a positive impact on urban African American students' academic achievement and participation (African American students made up the second largest ethnic group in Kahle et al's project). Their study showed that up to 15% of the difference in African American students' scores was attributed to differences in teaching practices. Kahle and her colleagues' (2000) findings corroborate the arguments presented in the previous section. In other words, teachers' professional development is one of the key factors influencing student achievement; therefore, if teachers are provided with meaningful opportunities to improve their pedagogical content knowledge, all students—including traditionally underserved students—will benefit.

Unfortunately, not all the states that participated in the SSI program were as successful. In fact, out of the 26 states that were funded by the National Science Foundation, and after five years of funding, the Puerto Rico Statewide Systemic Initiative (PR-SSI) was one of the very few states that showed more promising progress in the reform of science and mathematics education at a system-wide level (Rodriguez, 2001b, 2000). This is worthy of further analysis here, but it is important to first consider another type of large-scale funding—the Urban Systemic Initiative (USI). The USI Program was very similar to the Statewide Systemic Initiatives (and it was also sponsored by the National Science Foundation), but the USI focused on supporting reform efforts at a citywide level. Some of the USIs also met with some success; therefore, I will first describe some of the general characteristics of the USI Program below. This will be followed by a contrast analysis of what made one statewide reform program (the PR-SSI) and one urban systemic initiative (the Miami-Dade USI) most promising in terms of having a positive impact on teacher professional development and on student achievement and participation.

The Urban Systemic Initiative Program

Since 1993, 22 large urban school districts have been funded as part of the Urban Systemic initiative Program, with the largest cohort of school districts (a total of 8) funded during the first year of the program. At the core of the USI was the effort to apply lessons learned from the Statewide Systemic Initiative Program. Thus, the National Science Foundation stated, "all children can learn if they are provided with rich learning environments" (Kim, Crasco, Smith, Johnson, Karantonis, & Leavitt, 2001, p. 3). This meant that all participating school districts were expected to implement district-wide changes that included "standards-based curriculum and instruction, aligned assessment, professional development for teachers, convergence of educational resources, and community partnerships" (Crasco et al, 2001, p. 3).

So far, the USI Program has impacted the education of 4.5 million children in urban centers with a large population of students from low-income families (about 69% enrolled in the free or reduced lunch program) and from diverse cultural backgrounds (about 80%) (Crasco et al, 2001). Some of the funded USI's (such as the Detroit USI) had a predominantly African American student population; whereas other USI's (such as the Miami-Dade USI) had a predominantly Latina/o student population. However, in most cases, USI de-tracking policies, standards-based curriculum, and focus on teacher professional development made a promising impact on *all* students' achievement and participation in science and mathematics courses (Rodriguez, 2001b, 2000; Crasco et al, 2001; Kahle et al, 2000).

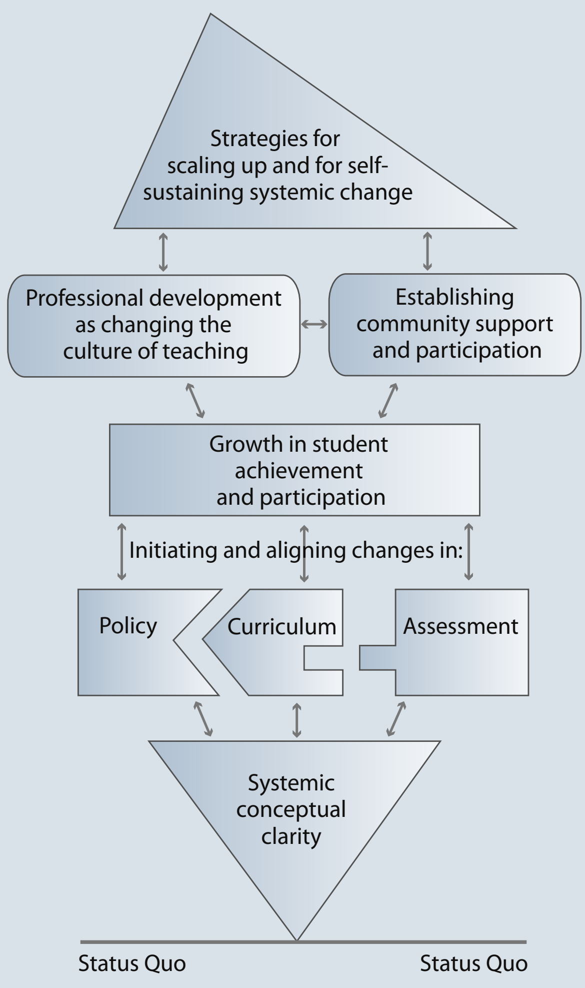
An in-depth discussion of each of the USIs is not the focus of this monograph, but an analysis of two of these education reform programs is offered below to illustrate some of the factors that made these large-scale initiatives promising.

A Tale of Two Promising Cases: Contrasting One Statewide Educational Reform Program with an Urban Program

The Puerto Rico Statewide Systemic Initiative (PR-SSI) and the Miami-Dade Urban Systemic Initiative (Miami-Dade USI) were selected from among many other cases because of their efforts to reform mathematics and science education simultaneously, their high population of traditionally underserved students, their high population of students in the free or reduced lunch program, and their innovative and promising approaches for enhancing the achievement and participation of all students in science and mathematics. In addition, due to Puerto Rico's centralized education system, it can be considered the second largest in the United States (650,000 students) and one of the poorest. According to federal guidelines, in 1999, 79% of all students in Puerto Rico qualified for the free and reduced lunch program; whereas in Miami-Dade county (with 352,595 students), 59% of the student population qualified for the free and reduced lunch program (Rodriguez, 2000).

These two promising cases are analyzed and compared with one another in more detail in Rodriguez (2000). However, it should be noted here that after conducting in-depth interviews with key officials from both of these initiatives, and after reviewing all the available performance reports, curriculum materials, and some teacher workshop documents, it was evident that *systemic conceptual clarity* was the conceptual "glue" driving the systemic reform efforts for both the PR-SSI and Miami-Dade USI. Systemic conceptual clarity is defined as the shared vision that enables all those involved in the reform enterprise to work toward the same goal regardless of the different demands, challenges and/or advantages the various components of the reform effort may face. Just like having a vision for how to put a complex puzzle together, those involved in the reform effort work diligently to make their respective "puzzle pieces" fit the larger picture. This is not an easy feat, as one of the Miami-Dade USI officials stated that working in large-scale reform was like "jumping on a fast moving train" (Rodriguez, 2001b). To better appreciate how officials maintained the systemic reform train moving on the right track, Figure 17 illustrates how systemic conceptual clarity (represented by the inverted pyramid) served to maintain the difficult but necessary balance of key PR-SSI and Miami-Dade USI elements. Figure 17 does not imply a lineal model. One finding from the analysis of these two case studies is that for systemic reform to be systemic—all of the elements shown in Figure 17 must be perceived as closely connected and dependent on one another for the success of the whole project.

Figure 17 A framework of systemic reform in science and mathematics education: the Puerto Rico Statewide Systemic Initiative and the Miami-Dade Urban Systemic Initiative



Source: Rodriguez. (2000)
Note: This figure represents the author's conceptualization of systemic reform.

For example, the PR-SSI used recently passed legislation to reform schools in Puerto Rico as leverage for simultaneously spearheading the reform of the mathematics and science curriculum. Tied to these reform initiatives was the PR-SSI push for having a Spanish version of the NAEP in place so that a baseline of student academic performance could be established. At the same time, increased high school requirements for graduation, aggressive de-tracking policies, and intensive teacher professional development institutes were being implemented to move the reform efforts forward. Similarly, the Miami-Dade USI aligned the mathematics and science school curriculum to national standards simultaneously, implemented de-tracking policies, and conducted professional development institutes that focused on student-centered and inquiry-based learning.

The PR-SSI and the Miami-Dade USI had many things in common, but one important difference between these two large-scale reform efforts was their *operational approach*. Findings from the analysis of these two case studies indicate the Puerto Rico SSI's operational approach was "whole school." That is, this strategy was unique in that it required *all* math and science teachers in one school to be involved in systemic reform activities for an extended period of time.

Table 6 Contrasting the impact of the PR-SSI and the Miami-Dade USI on student achievement

PR-SSI	Miami-Dade USI
• Reduction of achievement gap in math (by 16 points) and science (by 14 points) between students from SSI public schools and students from private schools (Data taken from the Spanish version of NAEP, administered in 1994). • Improved student achievement in the SENDA (a standardized math & English test).	• Reduction of achievement gap in the math applications component of the Stanford Achievement Test for grades 5 and 8 (African American students showed the most improvement). • Reduction of achievement gap in the science component of the Stanford Achievement Test for grades 3 and 5 (Latina/o students showed the most improvement). • Significant increase in the enrollment and completion rate of gate-keeping math courses by all students (67.2% increase in completion rate) and by students from diverse cultural backgrounds (83.7% increase in completion rate).

Source: Rodriguez. (2000)

In contrast, Miami-Dade USI's operational approach was based on a needs assessment/feeder pattern. This consisted of committing resources only to schools where specific needs (in terms of teacher development, student achievement or participation, and/or curriculum) had been identified. In addition, the Miami-Dade USI officials sought to include a set of schools that fed into others (i.e., elementary schools that fed into middle schools, and middle schools that fed into high schools) as a strategy to maximize the opportunities for long-lasting and self-sustaining change.

Even though the observed gains in student achievement from both of these initiatives were small,[16] these two case studies are good examples of promising cases of science and mathematics education reform at a large scale (see Table 6). Both the PR-SSI and the Miami-Dade USI showed student improvement in math and science standardized tests, and a definite increase in the number of students taking gate-keeping mathematics and science courses.

The latter was the direct result of aggressive de-tracking policies that took a lot of courage and management of those resistant to change. Given the short term for implementing the ambitious changes required by systemic reform, expecting an immediate and large reduction of the achievement gap is unrealistic. Instead, more attention should be paid first to better understanding the various aspects that make some educational reform efforts more promising than others. One place to start this process would be the construction of alternate forms of assessment to measure the impact of the new inquiry-based curriculum and of the alternate forms of teaching being encouraged. It is odd that systemic reform leaders continue to use standardized, multiple choice tests to measure the content knowledge, critical thinking, problem-solving, and socially relevant skills their new curriculum is professing. It is obvious, however, that the costs of using alternate forms of assessment are an obstacle that only funding agencies could help remove. This is an investment worth making to advance our understanding of systemic reform, and to make "science for all" and "no child left behind" more than just popular slogans.

[16] Even though PR-SSI students' gains in mathematics and science achievement were small, the PR-SSI was one of the most promising compared to all other SSI projects, and one of only three that were funded for a second term.

Conclusion

Courage, Hope and Charting New Paths

Given the pervasive social inequities that afflict diverse students in today's schools, we cannot respond with complacency. Complacency takes no courage. It entangles the mind in a web of cynicism and fills the spirit with paralyzing despondency. If we learn to celebrate our successes one lesson at a time, one student at a time…just one day at a time, we shall begin to build the alliances with colleagues, administrators, parents, researchers, and students necessary to make science education reform efforts an on-going and responsive project. The promising cases of science education reform projects highlighted here[17] clearly indicate that the reform enterprise must be a collaborative effort in which multiple stakeholders converge their unique positions of power, resources, expertise and strength of spirit into the school reform project. This is, of course, not easy and marked among many things by our contradicting desires for quick fixes, yet hopes for long-term positive change. Deborah Meier eloquently describes our impatience with the change process as follows:

> Small, democratically run schools are both quintessentially American and hard for Americans to swallow. They appeal to our spirit of independence, but not our impatient desire for guaranteed fixes and standardized products. In the face of vast school failure, such reforms argue for fewer rules, not for more of them. They smack of a kind of trustfulness that a heterogeneous and complex society finds reasons to be wary of (1995, p. 37).

Perhaps, the following summary would assist those interested in long-term positive change to ignite science education reform in their own contexts. The summary includes some of the main features that made the projects discussed here promising cases of successful science education reform. There is no silver bullet, however. Many of these features will have to be adjusted to the realities and specific contexts of each school for them to take root.

Summary of Suggestions for Reforming Science Education

Communication

- Facilitate teacher-to-parent, teacher-to-student, and parent-to-child communication workshops. These workshops should include information on college requirements for various programs and financial aid.
- Require each student to have a career plan by the end of grade 10 in collaboration with school counselors, teachers and parents.
- Facilitate and nurture a community of life-long learners that includes teachers, parents, and students. For example, have parents closely involved in student long-term and socially relevant projects that tie the curriculum to the community. These projects may include: a community/school garden, ecological studies of nearby parks, lakes or rivers, recycling/pollution, etc.
- Have key school documents and school newsletters available in the representative languages of the school community.

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[17] Even though several of the projects described in this monograph also involved mathematics education reform, and even though the suggestions for education reform can be applied across curriculum areas, the focus of this analysis has been on science education since that is the author's area of expertise.

- Facilitate and nurture collaborative partnerships with university faculty in the sciences, mathematics and education fields. For example, the professional development school model is an approach to university-school collaboration that has gained much positive attention in recent years (Holmes Group, 1995; Loucks-Horsley, Hewson, Love, & Stiles, 1998).

Teacher Professional Development

- Provide teachers with hands-on and minds-on workshops for assisting second language learners to achieve success in science.
- Acknowledge that resistance to ideological change (teaching for diversity) and resistance to pedagogical change (teaching for understanding) are common types of resistance found in school reform efforts. Therefore, teachers must be provided with many hands-on and minds-on opportunities to reflect on their own practice and on their belief systems, and to engage in honest professional development dialogues with peers and role models.
- Provide teachers with opportunities to engage in focused discussions of current research on teaching and learning that could help dispel stereotypes about various cultural groups.
- Provide teachers with the necessary equipment (including learning technologies) required to meet the expected science education standards.
- Establish professional development partnerships with university faculty (in the sciences, mathematics, and education) that encourage all parties to research and reflect on their practice. Learning to teach for understanding and for diversity must be a collaborative effort by which all involved learn from each other.

School Restructuring

- Eliminate tracking and instead place students in culturally and ability diverse groups where all students are expected to do their best work.
- Reduce class sizes. For instance, implement the National Commission on Teaching and America's Future's recommendations for school restructuring. That is, instead of having a school of 600 students being served by 24 classroom teachers, 26 other staff, with an average class of 25 students, and teacher planning for about 3.75 hours, establish a school of 600 students being served by 43 teachers, 7 other staff, with an average class size of 16 students, and 10 hours/week for teacher planning. In addition, restructure the school into three teams of 7 teachers each. Each teaching team works closely with 100 students (three teams work with students from the lower grade and three teams work with students from the upper grades). To enhance opportunities for professional development and the use of instructional technologies, a lead teacher and media/computer specialist devotes half of her/his time coordinating curriculum and visiting the team teachers' classrooms.
- Increase teacher salaries and provide more incentives for professional development.
- Establish interdisciplinary "houses" that allow students to stay with the same group of teachers for more than one year.
- Involve the teaching faculty in decisions having to do with course scheduling, special events, pedagogy, professional development, student management, and curriculum.
- Establish functioning high school homerooms in which a full period is devoted to building a community of learners and where real academic advising is provided.
- Establish systemic conceptual clarity by ensuring that all stakeholders are aware of the theoretical framework(s) guiding the reform efforts.
- Establish an operational approach that clearly states how the reform project will be carried out and the roles various stakeholders will play.

Curriculum

- Facilitate curriculum integration across subject areas.
- Move away from the "mile wide, inch deep curriculum" to fewer curriculum subjects and more time for long-term projects and in-depth study.

- Increase the academic periods (one hour for elementary and 1½ to 2 hours for high school).
- Implement curriculum that is tied to the cultural diversity of the community and that is socially relevant.
- Make clear connections between the local curriculum and the national science education standards.
- Facilitate integration of learning technologies across all subject areas.

Pedagogy

- Facilitate cooperative learning where students' interests and prior knowledge are valued and utilized.
- Implement culturally responsive teaching strategies by which students' cultural backgrounds and first languages become resources used to enrich learning for all students.
- Implement multiple forms of student assessment (portfolios, performance assessment, projects, student-centered laboratory activities, presentations, and so on).
- Facilitate conceptual clarity and implementation of the theories of learning guiding instructional practice. For example, if constructivism is the theoretical framework being encouraged, how are teachers supported to implement this framework in the classroom? What type of constructivism is being implemented—individual or social constructivism?
- Implement a variety of student-centered and inquiry-based pedagogical strategies that allow students to become aware of their own—and each other's—prior knowledge and of how scientists construct knowledge.

To close, it is important to keep in mind that whether school reform is supported by large- or small-scale funding, one thing is for certain: reform only begins the moment that one teacher starts teaching that one lesson using a new approach and the moment the students take notice of it. What happens next is dependent on the many factors discussed here and on our willingness to be patient, yet committed to effect change—committed to turning despondency into hope.

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Appendix

Terms Used

The labels we use to place individuals or groups of individuals are embedded in cultural and historical capital. For example, institutions use labels for convenience and simplicity—a way to distinguish "the Other" from the norm. However, commonly used "people labels" are colonial and emphasize superficial physical differences. For instance, even though colonial terms such as "Master" or "Patron" are unacceptable today, terms such as "Black," "White," "Indian" and "race" endure. Furthermore, even a new term was invented when the colonial use of "Spanish," "mulatto'" or "mestizo" was not appropriate to classify Latinas/os. Hence, the term "Hispanic" (meaning "of Spain") was created by the U.S. government in the late 70's.

Although I prefer to use words that celebrate and bring attention to the individual's ethnic and cultural heritage, I feel that I must compromise and use some of the more commonly accepted terms in this monograph for the sake of clarity. Even though these terms may not accurately represent the cultural diversity within the ethnic groups considered in this paper, I believe they are more inclusive. In any case, my goal is to celebrate the fact that we all have ethnic roots that cut across artificial boundaries, and that this is more worthy of notice than shades of skin color. Therefore, the following terms are used throughout whenever possible:

- *Latina/Latino* instead of *Hispanic*
- *African American* instead of *Black*
- *Native American* instead of *Indian*
- *Anglo* instead of *White*
- *Asian*
- *Ethnicity* instead of *race*
- *Underserved* or *underrepresented* instead of *minority*

The terms used to describe ethnic groups by authors cited in this paper were kept as they appeared in their original manuscripts.

Figures and Tables

Figures

Tables

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