Science & Math CESE Education

The

BEACON

News from

The Coalition for Excellence in Science and Math Education

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PRESIDENT'S MESSAGE—March, 2005

Marshall Berman

As usual, this has been a very active period for CESE. The nation's education system faces very serious problems. Two recent international tests, TIMSS (Trends in Math and Science Study) and PISA (Program for International Student Assessment) showed that US students demonstrated little or no improvement in math, science, reading and problem solving compared to many other industrialized countries. These tests assessed 4th, 8th, and 15-year-old students (approximately 10th grade). We present two discussions in this issue of the *Beacon*: TIMSS, by Steve Getty (CESE past president) and me; and PISA by CESE statistician Walt Murfin. Additional analyses of these assessments and their potential impact on the state and nation will be presented in future *Beacons*.

Intelligent Design (ID) people sought for the third time to have KNME, our local PBS affiliate, air their highly one-sided video, "Unlocking the Mystery of Life." Their first attempt was in May 2003. CESE objected because the video was essentially an infomercial for ID and did not represent good science. KNME agreed immediately and the show was cancelled. A year later, ID again brought up the issue. In May 2004, CESE responded again, but this time KNME demurred. We suggested that, if the video were to be shown, KNME should consider adding a disclaimer and/or a commentary by mainstream biologists. A month later, KNME told us that they did not "make programming decisions based on 'pressure' from any individual, group or organization." However, serious questions were raised concerning the funders of the video. Ultimately, that was the reason that the airing was cancelled.

On New Years Day 2005, we learned that the ID folks had struck again, and the video was scheduled for that Friday, January 7. Despite only a few days' notice, our members contacted KNME, and once again the video was cancelled, with the same rationale as in May 2004. This time, however, ID claimed censorship, and the issue was discussed on TV and reported in the print media. ID also ran an ad in the *Albuquerque Journal* claiming "unprecedented censorship." The New Mexico Academy of Science, in partnership with CESE and New Mexicans for Science and Reason, responded with an Op Ed in the *Albuquerque Journal* strongly supporting KNME's right to make editorial decisions based on their own policies, just as all the media do. Several of our members wrote excellent letters to the editor supporting KNME's stand. [John Trever published a cartoon making fun of ID that was also disparaged by the Discovery Institute, the "home" of ID.] In exchange for cancelling the video, KNME offered TV time for a discussion between two ID representatives and two of our members (Kim

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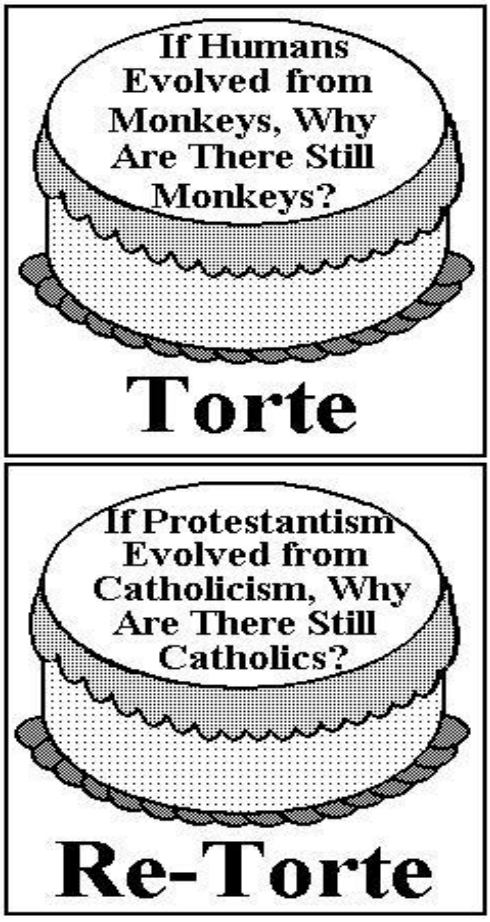
Johnson and Dave Thomas). . The ID people declined to participate in this venue.

This local KNME decision had national ramifications. PBS withdrew the video from its online library and informed their national board concerning following their funding policy.

On another front, CESE contributed to the development and approval of a charter school called Life Skills. The school is targeted to high school dropouts, and provides a second chance to get a diploma. CESE wishes the school success in its future endeavors.

Please mark your calendars for the **CESE Annual Meeting on Saturday, June 25th, at the UNM Law Library, Room 2402.** *Albuquerque Journal* editorial cartoonist John Trever will be our featured speaker.



Toon by Thomas

U.S. and INTERNATIONAL COMPETIVENESS – New 2003 TIMSS Results

Stephen Getty and Marshall Berman

How is the U.S. faring in preparing its students to compete in a global economy? Can we continue to be a leader in science and technology? Recent test results show that there are some major warning signs.

An important way to gauge our future standing in the international marketplace is by comparing academic performance on international assessments. The new international TIMSS (Trends In Math and Science Study) and PISA (Program for International Student Assessment) tests provide inter-country comparisons of student achievement. This article discusses the TIMSS results over the last nine years.

TIMSS—A Measure of Competitiveness in Science and Math

TIMSS tests were conducted in 1995, 1999, and 2003 (released in December 2004). The assessment framework used common content among participating countries.

In 1995, TIMSS included 42 countries at three grade levels: 4th, 8th, and 12th. In 4th grade, U.S. students did extremely well in science and above average in math, but U.S. students in 12th grade scored at or near the bottom. Four years later (1999) TIMSS-R repeated this study at 8th grade only.

The 2003 TIMSS results for 8th grade allow comparison among 32 countries that participated in 2003 and at least one prior study (1995 or 1999).

Here are the U. S. comparative scale scores.:

	1995	1999	2003
4th grade science	542	-	536
4th grade math	518	-	518
8th grade science	513	515	527
8th grade math	492	502	504

4th grade science: US was second only to Japan in 1995, but was sixth in 2003 with a slightly lower (but not statistically significant) scale score of 536. Singapore went from 523 to 565; Hong Kong from 508 to 542; England from 528 to 540.

4th grade math: US average score (518) did not change over the nine years. But some countries improved dramatically (e.g., Hong Kong from 557 to 575; Latvia from 499 to 536; England from 484 to 531; Cyprus from 475 to 510)

8th grade science: US students improved their scores (513-527) from 1995, but ranked 10th in 2003. Korea went from 546 to 558; Hong Kong from 510 to 556; Lithuania from 464 to 519.

8th grade math: US improved (492 to 504) between 1995 and 2003. US ranked 15th of 36 countries in 2003. Korea went from 581 to 589; Hong Kong from 569 to 586; Latvia from 488 to 508; Lithuania from 472 to 502.

Overall, U.S. student performance in math and science was stable, with improvements in some categories. In 4th grade math and science, TIMSS showed no improvement from 1995 to 2003. In contrast, 8th grade science did show some statistically significant improvement from 1995 to 2003, particularly the last four years. For math, 8th grade showed improvement over the interval 1995 to 2003, but with only modest growth the last 4 years. These trends in math at grades 4 and 8 are corroborated by the relative changes in two other independent studies of student performance. Known as "The Nation's Report Card," these are the long-term and the repeat NAEP studies (National Assessment of Educational Progress).

The rankings in Tables 1 and 2 show mediocre performance in science, and even weaker performance in math relative to participating competitors at both grade levels.

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The overall picture is of roughly flat performance levels in the U.S., with some improvements in select areas. But U.S. performance does not match the achievement levels of many key economic competitors in Europe and Asia. The results are significant because many of these students will be entering the U.S. workforce in about 5-15 years.

Building and Retaining A High-Quality Workforce

Average scores combined with the number of workers reflect both the quality and quantity of a future workforce. But more workers with higher-level skills will be needed in the U.S. to fill jobs in science, technology, engineering, and math (STEM). Without available workers here, many jobs will move to competitor nations. For example, the annual growth rate of STEM occupations since 1980 has been about 5%, compared with about 1% growth for the civilian workforce (NSB Science and Engineering Indicators 2004, http://www.nsf.gov/sbe/srs/seind04/). The STEM workforce is about 11 million in the U.S. (of a total civilian workforce of about 148 million). Projections to 2010 are for annual growth rates of about 5% for science and engineering jobs, and 8% for professions in math and computer sciences (U.S. Dept of Labor, Bureau of Labor Statistics). A key part of international competitiveness is keeping those jobs in the U.S.

The 2003 TIMSS and PISA results are good measures of the U.S.'s future ability to sustain and grow this high-quality part of the workforce. This can be shown by comparing the percent of students per country who are performing at high or advanced proficiency levels on the TIMSS assessments (Fig. 1). These students are most likely to have the skills needed to fill challenging jobs in science-related fields.

In 4th grade science, 13% of U.S. students are performing at or above a high level (>550). (Figure 1a)

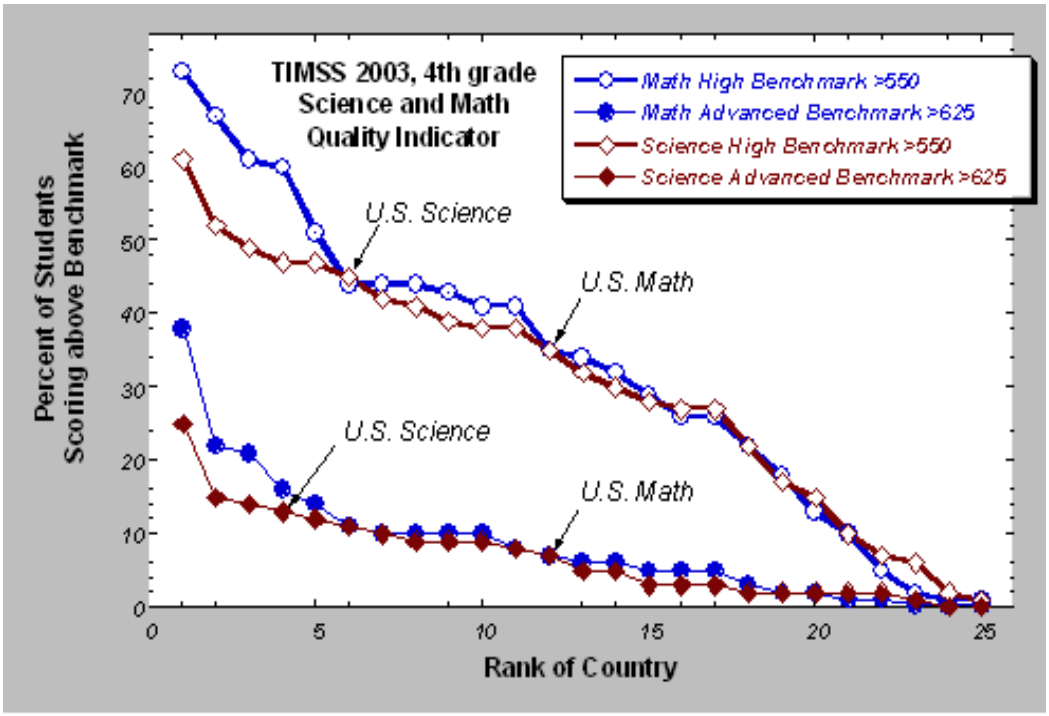

Figure 1a.

key economic competitors in

4th grade math performance is significantly lower: 7% above the advanced level and 35% above high level.

At 8th grade, the percentage of U.S. students performing at or above advanced (11% in science, 7% in math) or high (41% in science, 29% in math) levels is comparable to 4th grade, but the number of countries with higher fractions of students performing at these high or advanced levels has increased (Figure 1b). This shows that our economic competitors have larger fractions of students performing at high or advanced levels.

Competitiveness in Math and Science

Areas of some progress appear limited to 8th grade. At the same time, a comparison with key economic competitors in the 2003 PISA shows that U.S. is below average in science, math, and problem solving.

A second issue is how does change—or lack of change—in student achievement relate to reforms and new policies? How do the 2003 TIMSS results relate to factors such as curricula, instructional materials, educational technologies, or teaching practices? Tangible evidence to address this might be found in notable increases in TIMSS 2003 scores for 8th grade Physical Sciences and Earth Science. These fields have been clearly articulated in science standards and instructional materials over the past decade (e.g., National Science Education Standards, 1996), even though these fields are not the main content areas for middle school teachers.

Third, at all levels tested, the U.S. shows lower scores in math relative to science. Even though math is the language of science, math scores persistently lag science scores. Do poor math abilities inhibit or limit performance in science for U.S. students? Would higher math performance enable better science performance? Will poor math skills hinder students when they enter the workforce?

Fourth, the 2003 TIMSS (and PISA) results shed no light on one key economic competitor

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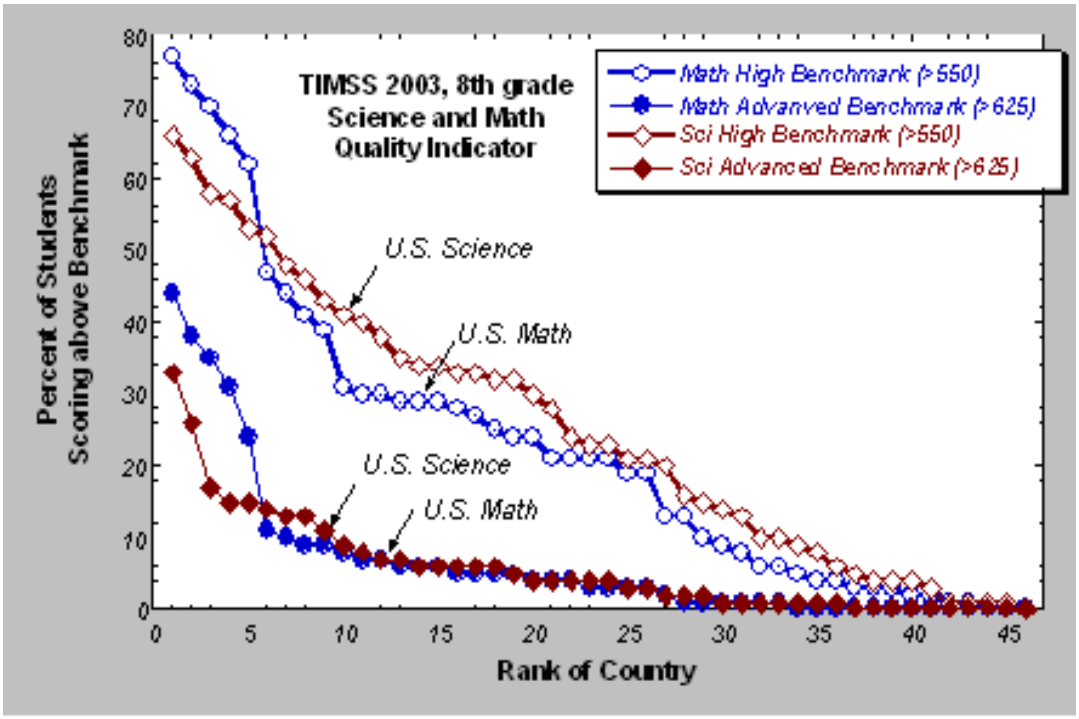

Figure 1b

Percent of students scoring above benchmarks of high or advanced in science and math at 4th (Fig. 1a) and 8th(Fig. 1b) grades. By 8th grade, many key economic competitors have a much higher fraction of students than the U.S. scoring at high or advanced proficiency levels.

http://www.cesame-nm.org

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—China. While many parts remain largely rural, China has also shown substantial growth in the quality and quantity of its workers. Many of these workers are completing graduate and post-graduate studies in top U.S. universities. Many now return to China as that economy supports more jobs, not just in manufacturing, but also in academic and STEM fields.

Fifth, several indicators show an increasing ability of Asian countries to compete in a global marketplace (e.g., Japan, China, South Korea, Malaysia, Singapore and Taiwan). These include rates of obtaining advanced degrees in science and engineering fields, investment in research and development, more articles published in leading science and engineering journals, and greater shares of the world market in high-tech products. High scores by students in these same countries suggest that they should be able to increase their competitive strength in these areas. It is unclear how the U.S. can increase, or even maintain, its competitive standing in a global marketplace while performance levels in math and science remain markedly low compared to other developed countries.

Table 1. TIMSS 4th Grade Math and Science 2003

Country	Math Mean	Country	Science Mean
Singapore	594	Singapore	565
Hong Kong	575	Taiwan	551
Japan	565	Japan	543
Taiwan	564	Hong Kong	542
Belgium	551	England	540
Netherlands	540	**U.S.**	**536**
Latvia	536	Latvia	532
Lithuania	534	Hungary	530
Russian Fed.	532	Russian Fed.	526
England	531	Netherlands	525
Hungary	529	Australia	521
U.S.	**518**	New Zealand	520
Cyprus	510	Belgium	518
Moldova	504	Italy	516
Italy	503	Lithuania	512
Australia	499	Scotland	502
New Zealand	493	Moldova	496
Scotland	490	Slovenia	490
Slovenia	479	Cyprus	480
Armenia	456	Norway	466
Norway	451	Armenia	437
Iran	389	Iran	414
Philippines	358	Philippines	332
Morocco	347	Tunisia	314
Tunisia	339	Morocco	304
math int avg	**495**	**sci int avg**	**489**

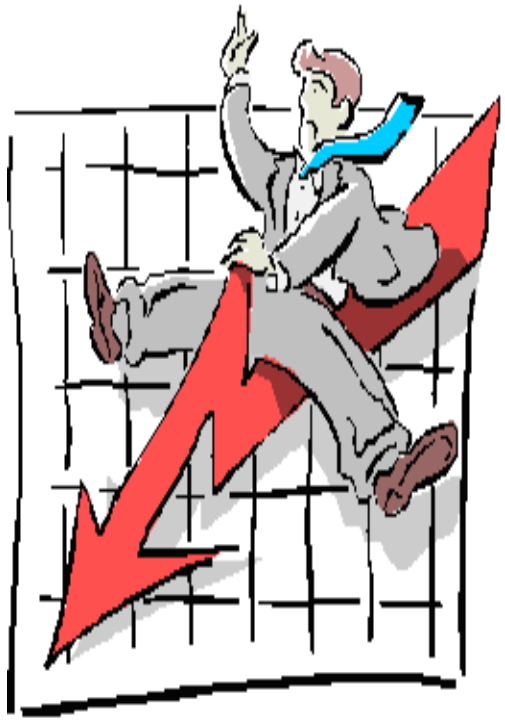
Countries in white adjacent to U.S.have results that are not significantly different .

Conclusions

We now have several international measures of student performance spanning almost a decade. Two independent but extensive tests show that U.S. students are performing well below our major global competitors in science and math. These assessments did not include the fastest growing economy in the world—China. Given that many of our manufacturing jobs have already vanished, and that we are even outsourcing many other professional jobs, the U.S. is facing vital economic challenges in the very near future. Success depends on the quality and quantity of a nation's workforce. And the preparation and motivation of this workforce depends on elementary and secondary education. The U.S. needs to do much better if we intend to retain our standard of living and compete into the 21st century.

Table 2. TIMSS 8th Grade Math and Science 2003

Country	Math Mean	Country	Science Mean
Singapore	605	Singapore	578
S. Korea	589	Taiwan	571
Hong Kong	586	S. Korea	558
Taiwan	585	Hong Kong	556
Japan	570	Japan	552
Belgium	537	Estonia	552
Netherlands	536	Hungary	543
Estonia	531	Netherlands	536
Hungary	529	Australia	527
Slovak Rep.	508	**U.S.**	**527**
Malaysia	508	Sweden	524
Russian Fed.	508	New Zealand	520
Latvia	508	Slovenia	520
Australia	505	Lithuania	519
U.S.	**504**	Slovak Rep.	517
Lithuania	502	Belgium	516
Sweden	499	Russian Fed.	514
Scotland	498	Latvia	512
Israel	496	Scotland	512
New Zealand	494	Malaysia	510
Slovenia	493	Norway	494
Italy	484	Italy	491
Armenia	478	Israel	488
Serbia	477	Bulgaria	479
Bulgaria	476	Jordan	475
Romania	475	Moldova	472
Norway	461	Romania	470
Moldova	460	Serbia	468
Cyprus	459	Armenia	461
Macedonia	435	Iran	453
Lebanon	433	Macedonia	449
Jordan	424	Cyprus	441
Indonesia	411	Bahrain	438
Iran	411	Palestinian Auth.	435
Tunisia	410	Egypt	421
Egypt	406	Indonesia	420
Bahrain	401	Chile	413
Palestinian Auth.	390	Tunisia	404
Chile	387	Saudi Arabia	398
Morocco	387	Morocco	396
Philippines	378	Lebanon	393
Botswana	366	Philippines	377
Saudi Arabia	332	Botswana	365
Ghana	276	Ghana	255
S. Africa	264	S. Africa	244
England*	498	England*	544
math int avg	**467**	**sci int avg**	**474**



U.S. Education?

*Estimates for England should be viewed with caution as the participation rate guidelines were not satisfied.

PISA-2003 and Status

The Organization for Economic Cooperation and Development (OECD) tested weighted samples of 15-year old students in the Programme for International Student Assessment (PISA). All OECD countries and several nonmember countries participated. The tests were given in 2000 and 2003. The 2000 tests emphasized reading, although math and science were included. The 2003 tests emphasized math, but also included reading and science. As a member of OECD, the United States took part in both years.

The scores were scaled to have a mean of 500 over all students in OECD nations with a standard deviation of 100 for both years. This does not mean that the difficulty of the tests was unchanged. If a nation's score decreased from 2000 to 2003, it does not necessarily mean that students were worse in any absolute sense. However, it does indicate a competitive disadvantage relative to other nations.

PISA calculated an Economic-Social-Cultural Status (ESCS) index for all countries. The index has a mean of 0.0 and a standard deviation of 1.0. Positive values of the index indicate that the average economic, social, and cultural status of students in that country was above the average of all OECD countries. The most important factors in the index are parents' occupational status, family wealth, and possession of "classical" cultural items in the home. Fifteen countries with above average status, including the U.S., participated in both years. Figure 1 compares U.S. math scores with the average of the other 14 prosperous or high status countries. Eight of the other countries showed an increase, one was unchanged, and five decreased. The average of the other 14 increased, whereas the U.S. decreased. Our disadvantage is actually worse than it appears in Figure 1. Japan, Hong Kong, Macao, and Korea have below average ESCS indexes, and are not included among the high status nations.

The change was similar in science. The U. S. score decreased eight points, and the average

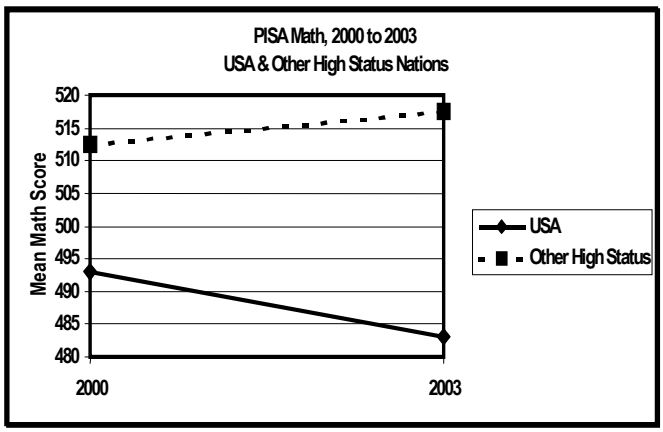


Figure 1. Mathematics Scores: U.S. and 14 other High Status Countries.

of the other high status countries increased about four points. Summary: The U.S. did poorly relative to other high status countries in both math and science and our relative disadvantage is getting worse.

When we look across schools, school ESCS status is more important than individual student status, but both are strongly correlated with scores. When we look across countries, the average status of all students in each country explains about 57% of the variance of national mean scores. The detailed relationship between status and scores is interesting. Although there are exceptions, more egalitarian nations – those that had only a small difference between the status of the highest and lowest status students – tended to have higher scores than nations that had large status differences. In fact, the status difference (range) explains almost as high a fraction of score variance as does the average status alone. The average status of the lowest quarter of students' status tends to be slightly more important than the average status of the upper three quarters. That is, the lowest status students, who typically have the lowest scores, sometimes drive the national average. Of 41 nations participating, only 12 had lower scores for the lowest status students than the U.S. Of those 12, the only European countries were Hungary, Portugal, Italy, Serbia, and Greece. The others were impoverished undeveloped nations.

Figure 2 shows the relationship between the mean status index and score for the U.S., for

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the average of all OECD countries, for Japan (a high scoring nation), and for Turkey (a low scoring nation).

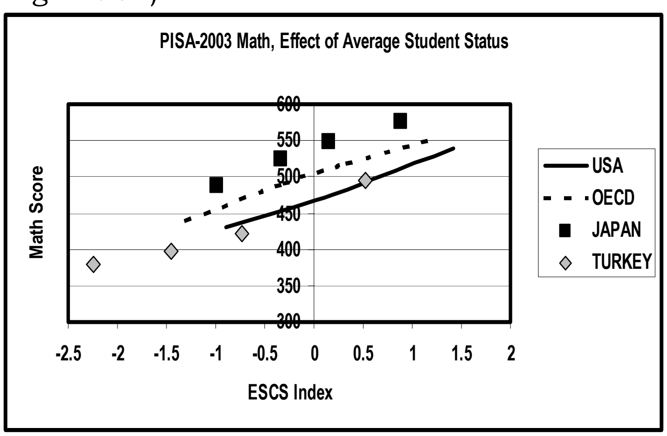

Figure 2. Relation Between Student Status and Math Scores.

Japanese students scored about 45 points above the international average at all status levels. American students scored about 30 points below the international average at all status levels. Japanese students did well in spite of lower economic, social, and cultural status. American students scored lower in spite of higher status. However, the low scores of Turkish students are indeed largely attributable to their considerably lower ESCS status. In fact, those Turkish students who do have higher status got scores almost identical to similar American students.

Conclusion A few American students did get respectable scores. They were generally students at the highest economic, social, and cultural levels. However, even those students did not do as well as high status students in most other countries, and did far worse than the highest status students in Liechtenstein, Belgium, Netherlands, Korea, and Hong Kong. Although the mean score for Turkey (423) is far below the mean score for the U.S. (483), American students do not have an advantage over Turkish students when status is taken into account. U.S. students scored well below other advanced countries in both math and science, and did worse in 2003 than in 2000 relative to other countries. Our students are at an international disadvantage in math and science and our position is worsening.

Walt Murfin
CESE Statistician

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