All of our children are competitors in a global economy: Are we leading them in the right direction?

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This paper reviews several indicators suggesting that the United States educational system is failing to provide the talent needed to keep the US competitive in a global economy. It examines the performance of US students in international assessments (TIMMS and PISA) and then compares some of the steps taken in the US intending to improve our performance with practices in countries performing well on these assessments.

Introduction

The USA has forged a powerful presence in the world based primarily on the strength of our economy. Our economic growth over the last century was due predominantly to developing new technologies. "Economic studies conducted even before the information-technology revolution have shown that as much as 85% of measured growth in US income per capita was due to technological change." (National Research Council, 2006, p. 1). Our continued success in an increasingly global economy must be built on the foundation of a skilled and innovative *next generation*. There is growing evidence that we may not be producing that generation with our current educational practices.

An awareness that something is seriously amiss in education in the USA prompted legislators to ask the National Academy of Science (NAS) to review the current condition of US science education and to recommend the top ten actions that Congress might take to insure that we remain leaders in innovation. The preamble to the ensuing report, *Rising above the Gathering Storm* (National Research Council, 2006), states

> Having reviewed trends in the United States and abroad, the committee is deeply concerned that the scientific and technological building blocks critical to our economic leadership are eroding at a time when many other nations are gathering strength.

Norman Augustine, Chairman of the NAS committee producing this report said further "America today faces a serious and intensifying challenge with regard to its future competitiveness and standard of living. Further, we appear to be on a losing path."

The online magazine, *Science Watch*, which tracks trends and performance in basic research, has compiled comparative data from 1990 and 2004 measuring the production of research papers in science, engineering and materials science. These data show 1) a steady decline in the USA's contribution to world science, 2) a steady increase in the contribution from Asia Pacific countries and 3) a relatively constant contribution from EU countries (Thomson Corporation, 2005). This trend is mirrored in the growing production of PhDs in science, mathematics and technology in China compared to the

declining numbers in the US. The United States faces a future where it is no longer dominant in the fields of science, mathematics and engineering.

The NAS report concludes by emphasizing the need to increase America's talent pool by vastly improving K12 science and mathematics education. Their recommendations include the annual recruitment of 10,000 science and mathematics teachers, the strengthening of the skills of 250,000 teachers and the enlargement of the pipeline of students graduating from college with science, technology, and engineering degrees.

Australia and New Zealand are as diverse as the United States. Finland is very homogenous but it was chosen because of its top performance. According to government census figures in 2001 23% of Australian residents were born overseas, while in 2002 only 10% of people in America were born overseas. A critical point is however that the other countries have much smaller populations and it is not clear how educational policies scale.

Performance of US Students on International Assessments

Evidence of the unsatisfactory academic performance of US students in mathematics and science comes from two major international studies of student progress. The Trends in International Mathematics and Science Study (TIMSS) tests students in grades 4 and 8 every four years. The cultural and economic diversity of countries participating in TIMMS is very wide indeed. In 2003 it compared the performance of US students with youngsters from 50 countries including Botswana, Mongolia, Denmark, Australia, Palestine, England, and Canada. TIMMS provides reliable and timely data on the mathematics and science achievement of US students compared to that of students in other countries. It is an achievement test, looking backwards at how well students have learned the intended and implemented curriculum.

The second study is the Program for International Student Assessment (PISA). This test is developed by the Organisation for Economic Cooperation and Development (OECD) and participation in PISA involves students from the major developed countries – countries responsible for roughly 90% of the world economy. PISA tests 15 year olds in mathematics, science and reading. The PISA study differs significantly from the TIMMS study in that it measures the *ability of students to apply their knowledge and skills to meet real life challenges*, whereas TIMMS measures the extent to which students have *mastered the taught curriculum*.

A summary of the performance of US students in fourth grade (1995 and 2003) and eighth grade (1995, 1999 and 2003) on TIMSS is displayed in Table 1. There has been no significant improvement by fourth graders in either mathematics or science over the period 1995 to 2003. There was a significant improvement for eighth graders over this period. In mathematics the improvement occurred between 1995 and 1999 with no further improvement from 1999 to 2003. In science the improvement occurred over the period from 1999 to 2003 (Ferraro & Van De Kerckhove, 2006). The minimal improvement noted by the TIMSS 2003 results are consistent with an assessment of internal testing associated with the No Child Left Behind (NCLB) program as analyzed by Harvard University's Civil Rights Project (Lee, 2006).

> By and large, the results of state-level NAEP trend analyses imply that NCLB's attempt to scale up the alleged success of the first generation accountability states (e.g., Florida, North Carolina, Texas) have so far not been effective. NCLB neither enhanced the first generation states' earlier academic improvement nor transferred the effects of their test-driven accountability policy to the second generation accountability states.

Table 1. Results from TIMSS tests in 1995, 1999, 2003 showing the performance of U.S. fourth and eighth grade students in mathematics and science.

Fourth Grade

Subject	1995 [600]	2003 [600]	Significant Change
Mathematics	518	518	No
Science	542	536	No

Eighth Grade

Subject	1995 [600]	1999 [600]	2003 [600]	Significant Change 95-99	Significant Change 99-03
Mathematics	492	502	504	+	No
Science	513	515	527	No	+

Comparing the performance of U.S. students on TIMSS with students from other countries, we can see that the U.S. students performed above the average. However, the TIMSS evaluations measure how well the students have learned the intended and measured curriculum. It does not test how well they are able to transfer and apply what they have learned. Eighth graders were outperformed in both mathematics and science by 9 countries and fourth graders by 5 countries (Ferraro & Van de Kerckhove, 2006, Tables C1 and C2). Considering the diversity of countries where the test was administered the above average performance of the U.S. was not exceptional.

Our focus for this discussion is on the PISA study for two reasons: first, the test cohort is drawn from countries that have more in common with the U.S. – all are members of the industrialized world and hence it measures like against like; and second, it provides essential information about how ready young people are to put their learning to use in the global economy.

So, where does the USA stand when compared with the rest of the world? A highly detailed review of the structure and wide ranging findings of PISA 2003 can be found in the document entitled "Learning for Tomorrow's World – First Results from PISA 2003" (OECD, 2003). The results of the performance of students in selected countries are given in Table 2. Also included in Table 2 is a measure of the standards of living in each selected country. This information comes from the United Nations Human Development Report 2006 (UNDP, 2007). It is a standard means of measuring well-

being, especially child welfare, by surveying a range of indicators and ranking the 177 countries surveyed.

Table 2. Results from PISA 2003 showing the performance of students from selected countries in mathematics and science.

Country	Standard of Living Ranking	Mathematics Score [600]	Mathematics Ranking [40]	Science Score [600]	Science Ranking [40]
Australia	3	524	11	525	6
Canada	6	532	7	519	11
Czech Rep.	29	516	13	523	9
Finland	11	544	2	548	1
Hong Kong	22	550	1	539	3
Japan	7	534	5	548	14
Korea	25	542	3	534	2
New Zealand	20	523	12	521	10
United States	8	483	28	495	22

On the PISA, the average score for both mathematics and science is 500. In both areas a total of 40 OECD countries participated. In mathematics the USA mean score was 483 and we ranked 28th. In science the USA mean score was 491 and we ranked 22nd. In both subject areas the USA performed below the OECD average. In mathematics we were outperformed by Korea, Japan, Australia, Poland, Hungary and others. In science we were outperformed by the Czech Republic, New Zealand, Canada, Ireland and others. The top performing countries in both surveys were Finland, Korea, and Hong Kong (SAR). (SAR stands for Special Administrative Region – a familiar name for Hong Kong. Hong Kong is part of the Peoples Republic of China but remains autonomous in many administrative functions such as education.)

It is alarming to see that our 15 year olds are being out performed in both science and mathematics by countries which have significantly lower standards of living than our own. Furthermore, PISA examines students' self concept in mathematics and finds that U.S. students are the most confident of their ability in mathematics (OECD, 2003, p132). Thus while our students perform below average they think more highly of their ability in mathematics than students from any other country.

Another interesting feature of the PISA study is a comparison between each country's performance in mathematics and the national expenditure on education per student (adjusted to reflect differences in each country's economies) (OECD, 2003, p 100). Figure 1 displays this comparison. The USA spends more money on education per student than most other nations and yet is achieving significantly below nations whose per capita spending on education is far less. The upward trend of this graph indicates that,

in general, spending more money can improve performance. However, the particular position of the United States demonstrates that, at the present time, we are not spending our money effectively. Clearly we are not going to make this educational dilemma go away just by throwing large amounts of money at it, but a considered effort to improve the quality of teaching like that suggested by *Rising above the Gathering Storm* may work well enough to justify the additional expenditure.

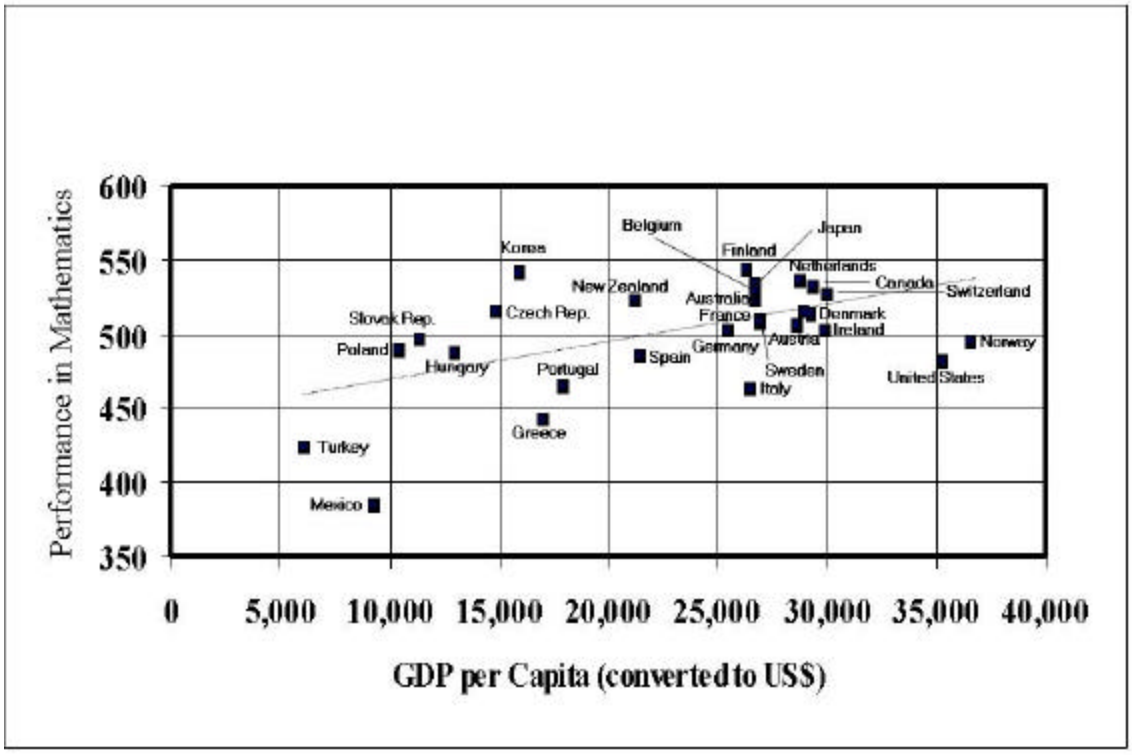

Figure 1. A graph showing student performance in mathematics on PISA 2003 versus the spending per student (OECD, 2003, p. 100).

Steps Taken to Improve Our Situation

A variety of steps have been taken by schools across the USA in attempts to improve the educational achievement of our students. It is informative to examine some of these steps and compare them to the practices of other, more successful nations (especially Finland whose overall performance was the highest). In general, the U.S. response has been in a direction opposite to the practices of countries performing well on international achievement tests.

Extended time in school

One possible method of improving student performance is extended time at school either be means of additional/longer days or younger starts in full time education. Finnish children enter school at age 7 and then only for half days. In Australia and New Zealand children typically have a 30 minute free play break mid morning, 45 minutes

free play at lunch and 2 hours of sport each week as well as regular physical education (Department of Education and Early Childhood Development (DEECD), 2006). In much of the USA, children begin full time school at 4 and have only a 15 minute free play recess each day. The OECD report "Education at a Glance 2006" (OECD, 2006, p. 58) lists teaching hours per year in lower secondary education for the 28 countries surveyed. The USA ranks first with just under 1,100 hours per year while Finland ranks 22nd with 700 hours per year. Others have observed the difference between the Finnish approach to the time spent by children in school and the policies of their countries; Sean Coughlan, a BBC reporter, has visited Finland and written of his impressions.

> From the Finnish perspective, they [the Finns] wonder why English school children start so early - and say that by the age of seven, pupils are just about mature enough to begin learning. Similarly, the long school holidays, including a 10-week break in the summer, is another part of their traditional school pattern that doesn't seem to have been troubled by English anxieties over "learning loss" over the holidays (Coughlan, 2004, n.p.).

Centralized control of curriculum

Many state departments of education and local school districts are taking tighter ***centralized control*** of curriculum content. The argument is that if we can make sure every child is taught the same content and regularly tested on that content we can implement greater accountability measures for those responsible for student achievement. In Finland, however, schools draw up their own curricula within broad national parameters (Ministry for Foreign Affairs of Finland, 2006) –"The Finnish school system is based on a culture of trust, not on control, and teachers are active in developing their own work."

In Australia the focus is on 'big questions' rather than specific content and similarly in New Zealand the national curriculum focuses on major learning principles and broad educational aims and individual schools design specific curriculum content that meets local needs and interests (New Zealand Ministry of Education, 2006).

Accountability

In the USA, ***accountability*** has become the catch word for better education. "No Child Left Behind" legislation has rolled out a blanket of frequent testing across the schools of this nation. And yet in Finland, the highest performing OECD nation according to PISA, no grading is used in assessment of younger children's learning and at the end of comprehensive schooling at age 16 there is no formal exam or certificate. In New Zealand a light sample of around 3% of students at ages 8 and 12 are tested in a three or four year cycle to build up a national picture of student achievement over time (New Zealand Ministry of Education, 2006). In Australia there is a complex mix of teacher designed and administered and state designed and administered assessments. Testing must focus on authentic tasks that reflect real world situations (DEECD, 2006). "During the first years of learning in primary schools (K-6), teachers aim to create a safe

and happy environment where students are valued, praised and encouraged rather than constantly tested."

We conclude this section comparing U.S. practice with that of other countries with three observations. First, the NAS report recommends the recruitment of large numbers of highly qualified K12 science and mathematics teachers and the strengthening of the skills of teachers currently in the teaching service. It is worth commenting that we will never attract the best and brightest into teaching until their remuneration reflects the salaries they could be realistically earning in other similarly qualified professions.

Second, a recent newspaper article ("Several Schools", 2007) credited the increased use of "scripted lessons" to the district's improved performance on standardized tests. Placing highly skilled teachers into struggling schools and then expecting them to teach tightly scripted lessons is no way to support a creative and innovative teaching profession.

Third, if we hope to improve the performance of our science and mathematics students in the global context, we need to work on a far broader scale. We presently, as we tinker with scheduling, impose standardized tests and tightly control curriculum. It is imperative that we look closely and openly at the practices of other countries and learn from their successes. We need to attract intelligent energetic teachers by guaranteeing reasonable remuneration. In addition we need to address the training of our science and mathematics teachers to ensure that they have both the discipline knowledge and the pedagogical knowledge and skills to teach effectively. We then need to trust and support them as they do what they have been taught to do – teach students science and mathematics in innovative, creative and engaging ways.

Conclusions

We have presented some of the conclusions of the National Academies report indicating concern about the way we are preparing our children to compete in a global economy; we have discussed the real performance of our students as demonstrated by their performance on TIMMS and PISA and then compared some of our strategies with those of more successful countries.

When we compare our students' performance with those in other developed nations what do we find?

- we spend more money on education,
- we teach children longer each day,
- we start school earlier
- we control the curriculum more tightly,
- we test more often,

and yet we get poorer results. Something is seriously wrong.

As we have argued, the United States is facing a changing world with globalization and evolving telecommunications technology providing more and more competition for our industry. To maintain our position (and to continue to support the development of emerging nations) we must continue to be the technological innovators we were in the last century and to do this we must have a steady supply of talented young

people interested in science, mathematics and engineering. This supply of talent must include women and minorities. The inclusion of women and minorities in careers in science and engineering is not only a matter of equity but a matter of national need. The following quotation is from a report commissioned by the National Academy of Science titled "Who Will Do the Science of the Future?: A Symposium on Careers of Women in Science" (National Academy of Sciences, 2006)

> If science is to continue to prosper and move forward, we must ensure that no source of scientific intellect is overlooked or lost. This means including women and ethnic minorities as active participants in the scientific enterprise.

To compete in a global economy we must help ALL our talented children to become innovators. The social costs of having the required innovation come from off shore are inestimable.

Perhaps we are paying the price for having been the most prosperous and powerful country on the planet. We have been historically rich in both physical and intellectual resources for a very long time. Innovative scientific and technological development has been the foundation of this nation's proud reputation and economic success. The highest levels of expertise could always be found within our own borders. But these things are changing.

The National Association of Elementary School Principals 2007 conference keynote speakers and distinguished lecturers are all representative of the American experience and all the featured authors reflect the USA. In 2007 the annual conference of the Association for Supervision and Curriculum Development (ASCD) provides a feast of American fare. Only 9 out of some 116 ticketed sessions are presented by people working outside the USA and none of these address the critical questions – what are other countries doing that produce students who can outperform our 15 year olds in science and math? The National Science Teachers Association (NSTA) is moving in the right direction. NSTA president Michael Padilla (2005-06) has expressed the need for greater international collaboration (Padilla, 2005),

> Moving forward, the NSTA International Task Force is proposing a plan to encourage and promote international collaboration. We envision that North American science teachers will have much to learn from teachers in other countries about both their culture and their successful teaching practices. This will allow us to better serve the diverse students we teach. In turn, science educators from other countries can learn much from us.

However, an examination of the featured speakers for the 2007 NSTA conference reveals that 3 are from foreign countries and 22 from the U.S.

Our survival as a major economic and political power in the world is at risk if we cannot maintain our competitiveness in scientific and technical innovation. It simply isn't good enough that our 15 year olds are performing below average compared with the rest of the developed world when asked to apply their scientific and mathematical learning. It is time we conceded that while we have a rich resource of educational theoreticians and

practitioners within our shores, we must turn our focus to the rest of the world and acknowledge our need to learn from them. Those who set policies and directions for the future of U.S. education need to look closely at the successful practices of other nations and learn from them.

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