One Nation Under-Taught

Solving America's Science, Technology, Engineering & Math Crisis

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Educate and inform the whole masses…They are the only sure reliance of the preservation of our liberty.

—Thomas Jefferson—

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Foreword

by Steve Forbes

As a nation, we have known for decades that our K-12 education system is in serious trouble, th our students routinely lag their counterparts in numerous other countries in language ar mathematical skills. This is especially worrisome in an era in which high tech is becoming more ar more critically important for advancing economically. That millions of our children are not bei taught effectively—or at all—in the crucial areas of science, technology, engineering and mat popularized by the acronym STEM, is a moral outrage. Their opportunities to get ahead, to "impro their lot in life," as Abraham Lincoln put it, are being seriously harmed and our future well-being as nation is being jeopardized.

Thankfully, America has a tradition dating back to Colonial times of not being passive when serio challenges arise. Vince Bertram is a splendid example of this can-do, let's-roll-up-our-sleeves-an do-something-about-it characteristic. His organization, Project Lead The Way (PLTW), has bee tackling the STEM deficiencies in our primary and secondary schools for a decade and a half. PLT has become the leading provider in the U.S. of STEM programs for kids in grades K-12. In addition coming up with world-class curriculums Dr. Bertram and his colleagues have created supe professional development programs for teachers. More than 6,000 schools around the country ha benefitted from PLTW's crucial work.

Dr. Bertram understands that it's not enough to come up with solutions, that you must also active work with students, parents, teachers, administrators, parents, universities, businesses ar foundations, as well as community and government leaders to affect lasting, positive chang Interacting with all parties—brainstorming, if you will—can also generate new ideas on how to mo forward.

While PLTW has made powerful contributions, so much more remains to be done throughout th nation. Hence, the crying need for Vince Bertram's new book. It couldn't be more timely, recognition of our STEM educational deficits is growing. Dr. Bertram brings immense knowledge ar expertise to the subject and speaks from frontline experience.

Dr. Bertram lays out the irrefutable evidence of the crisis: of how, since the mid-1960s, America students have been slipping in what they actually learn in our schools, especially in the STEM field According to the National Assessment of Education Progress, only 26 percent of American hig school seniors in 2010 scored at or above the proficiency level in math. More ominously, a staggerin 36 percent had failing scores. Worse, only 3 percent scored at an advanced level in math, and a pitif 1percent in science.

No wonder so few U.S.-educated high school students go on to pursue STEM courses in college. N wonder our high-tech centers, epitomized by Silicon Valley, must recruit literally hundreds thousands of foreign-educated people to try to fulfill their needs for skill-based workforces. Even wi that, huge gaps remain, which is why companies have to set up facilities overseas to meet the requirements.

All of which, of course, begs the question: Why don't our schools do a better job?

It's not as if we don't know we have an enormous problem. Back in 1983, the state of education ha gotten so bad that the then relatively new Department of Education released a report titled "A Natio at Risk." The ominous opening words from that report were powerful and tough and are worth r quoting at length:

Our Nation is at risk. Our once unchallenged preeminence in commerce, industry, science, and technological innovation is being overtaken by competitors throughout the world. This report is concerned with only one of the many causes and dimensions of the problem, but it is the one that undergirds American prosperity, security, and civility. We report to the American people that … the educational foundations of our society are being presently eroded by a rising tide of mediocrity that threatens our very future as a Nation and a people. What was unimaginable a generation ago has begun to occur—others are matching and surpassing our educational attainments.

If an unfriendly foreign power had attempted to impose on America the mediocre education performance that exists today, we might well have viewed it as an act of war. As it stands, we hav allowed this to happen to ourselves. We have even squandered the gains in student achievement mad in the wake of the Sputnik challenge. Moreover, we have dismantled essential support systems whic helped make those gains possible. We have, in effect, been committing an act of unthinking, unilater educational disarmament.

Our society and its educational institutions seem to have lost sight of the basic purposes schooling, and of the high expectations and disciplined effort needed to attain them.

Alas, while we have poured immense sums into our education bureaucracies, these increase resources have had little or no effect. We experimented with reforms that were as bad in conception they were in reality. And we continued to adjust down to mediocrity—or worse. As those numbe from the National Assessment of Education Progress attest, our students' scores over the pa generations have been, as education expert Chester Finn Jr. put it, "Flat, flat, flat."

We largely failed in fighting back against this "rising tide of mediocrity." Mediocrity does n sustain itself: One is either advancing or sliding backward. It's been said that what goes on in nation's classrooms will eventually work its way up to a nation's governance and economy. We se that, we live with that today.

Of course, we have pockets of excellence in some of our nation's schools—Dr. Bertram and h team have been immensely helpful here. But they are pockets, not the norm. Too many of our studen drop out of STEM fields, seeing them as boring or too difficult, and this aversion starts in the ear elementary grades.

It's here that we get to what makes Dr. Bertram's book such a timely gem and an excitin contribution. Vince Bertram does far more than lament our predicament. He provides a blueprint f enabling students to fall in love with STEM subjects—subjects that don't have to be dreary intimidating. He shows how teachers can break away from the rut of traditional teaching and kindle kids that inspiring curiosity that will lead them to becoming passionate about learning.

Dr. Bertram is no armchair reformer. He's been in the trenches as a teacher, principal an superintendent. Through PLTW he has implemented programs that actually work. And, ver importantly, his programs have equipped teachers with the intellectual and practical tools necessary teach STEM subjects well. Students quickly come to see the true relevance of these subjects in today world. They become inspired.

This is why we, as a nation, must "ramp up" the kinds of reforms Dr. Bertram and his colleagu have so successfully put into practice. The time for talk and ineffectual actions is long, long pas Vince Bertram shows us the way.

Author's Note

When problems arise, many people are inclined to blame someone or something. This book is n
about assigning blame. It is about clearly articulating the problem and taking responsibility to solve

We have many highly effective educators who are doing extraordinary work with students; loca
state, and federal policymakers who care deeply about their communities, states, and countr
mission-driven non-profit organizations working to enhance the lives of those they serve; ar
businesses striving to win in a highly competitive global marketplace. But, despite all these effort
we are falling behind in educating our youth and our future workforce and we must do somethi
about it.

This is a different kind of business and education book than most may be used to, and it is not ju
about science, technology, engineering, and math (STEM). Those subjects are a series of courses
disciplines. This book is about the importance of those subjects, yes, but, more: it is a book about ho
we integrate and use STEM knowledge. It is about how we inspire a thirst for STEM education. It
also a book about American greatness and our economy. This book is a call to action: asking teacher
principals, counselors, parents, business and community leaders to impart knowledge and experienc
they may very well not have had themselves.

This is a call to nurture our children's natural curiosity, inspire them, and insist they use their min
to solve problems. This book asks us to rethink the way we think about school. It asks that we abando
the mindset that second grade is a preparation for third grade or of teaching content merely to prepa
for a test. Instead, I am asking for a new mindset about school, a mindset that our schools can l
places of confidence, places that inspire a love of learning, promote curiosity, and convince studen
that skills and knowledge matter—not because they are on a test or necessary for the next year, b
because they matter for a lifetime.

I wrote this book because I believe if we do not change our present course, we are preparing to
many of our children—and too many in our country—for a lifetime of poverty. That is why we mu
be realistic and tell our children, and our graduating high school and college seniors, the trut
Commencement addresses at these graduations are rife with advice telling students to "follow yo
dreams"—this is often misguided advice, often very bad advice. For us to live in a world where th
advice were applicable or led to success, there would need to be a lot more jobs for profession
athletes and Broadway performers. The reality is, dreams may be incongruous with real job prospect
with simple reality. For example, throughout school, many children spend their evenings at spor
practice, and even more nights dreaming of being a professional athlete. However, ninety-nine perce
don't make it.

It sounds harsh, but it is the reality. Only a very small percentage of students will ever play in th
NFL. In fact, according to Business Insider and the National Collegiate Athletic Association (NCAA
only 1.7 percent of college football players will play in the NFL, and only 1.2 percent and 0.9 perce
of basketball players go on to play in the NBA and WNBA, respectively. This is of those who make
to the NCAA in the first place. The best opportunity is baseball, which Business Insider/NCAA repor
offers an 11.6 percent chance for college athletes to go pro (for many, that means playing years in th
farm system, hoping to be called up to the major league). And it's not just athletics. The same sma
percentages apply to music and the arts—Adele and J.K. Rowling are exceedingly rare talents, and s
were Pablo Picasso and Frédéric Chopin.

So what do we tell our kids? We tell them to pursue their passions, whatever those passions mig
be—the arts, music, sports—because you never know who might be talented and lucky enough

make it to the big leagues. We also need to be honest with our children and tell them that while the can choose which path to take, others will likely decide whether they will get paid to do it. Life will b easier—much easier—if they have the appropriate skills aligned with the greatest opportunities.

So in what fields will students find the greatest potential for success? Forbes highlights the most in demand college majors—the fields that will present our graduates with the most job prospects an highest earnings. Engineering and math fields dominated the list, with engineering concentration making up one-third of the most valuable majors. Biomedical engineering ranked #1; software engineering was #4, followed by environmental engineering (#5), civil engineering (#6), an petroleum engineering (#7).

These findings are nothing new, however. I've written often about the issues the STEM skills gap creating and how they greatly threaten America's economic competitiveness. By 2018, STEM jobs a expected to grow at a rate nearly double that of other fields—17 percent versus 9.8 percent. A estimated 1.2 million STEM jobs will go unfilled because the workforce will not possess the skills fill them. And, as the world continues to innovate and as new technologies emerge every day, the job gap will widen. So what can we do?

The answer is clear. We must reach our students earlier, introduce them to math and science, an show them the engaging, exciting, and practical applications of those subjects. We must continue t foster curiosity and collaboration, critical thinking and problem-solving skills, and stress to o students that the purpose of education is to prepare for the global economy, an economy that demanding more graduates with STEM knowledge and skills. We must counsel our students from a early age, introduce them to available career options, and guide them on the path to pursue tho careers with the appropriate course work and activities. We must encourage our students to begi thinking about their careers long before they finish high school.

The bottom line is this. Students should continue to pursue their passions and the dream becoming the next Peyton Manning or LeBron James. But let's also set them up with a sol foundation for a successful and stable life just in case the scouts don't call. And if your child student does end up within that rare .08 percent of athletes who go pro, a strong academic foundatio will give them security. Studies show that within two years of retirement, seventy-eight percent former NFL players have gone bankrupt or are under financial stress. We must help our children hav a brighter future through a career they can pursue once their dream career ends. And for the oth group—the majority 99.02 percent—opening their eyes to the career possibilities of their future wi excite them and inspire them, and give them a new dream to pursue. A dream that leads to a successf life.

Like many of my colleagues, I was attracted to education because of influential people in my li who inspired me to be more than I thought I possibly could be. Now, we need to be that inspiration f millions of children across our great nation.

This book is about the problem and the solution. Let's go to work.

Failing Ourselves

In 2013, the National Assessment of Educational Progress (or NAEP, known as "The Nation's Repo Card") revealed that only twenty-six percent of our nation's twelfth graders were scoring at or abov proficient in math while thirty-five percent were failing.[1] To put it another way, almost forty perce of Americans about to enter the workforce, military, college, and achieving voting age do so unable perform basic mathematics. That is, they cannot, among other things, "compute, approximate, a estimate with real numbers" or "order and compare real numbers and perform routine arithmet calculations with and without a scientific calculator or spreadsheet."[2]

Here, astoundingly to me, is a sample question from a recent NAEP math test for high scho seniors, a sample question nearly forty percent of our nation's seniors got wrong:

360 x .03=
a) 10.8
b) 108
c) 120
d) 980
e) 1,080[3]

Almost fifteen percent of the respondents selected answer "d" or "e," which is to say almost fifte percent of our nation's high school students thought three percent of 360 was a number greater tha 360.

The larger point here is that the state of American STEM education is not good. Indeed, it terrible. As a result, we are depriving millions of children the opportunity for productive and gre careers, and depriving our country the workforce and brain-power we need. We are in crisis—a cris that it is imperiling our future economy and position in the world.

This is not to say that good STEM teachers, students, or programs do not exist. They do. What I a saying is that, as a general matter, our country is failing our students and itself. Consider a few mo statistics.

In measuring our fifteen-year-olds against their peers in other Organization for Econom Cooperation and Development (OECD) countries in the field of science in 2012, our students came twenty-first, below such countries as Estonia, Poland, and Ireland.[4] In measuring our fifteen-year-ol against peers in other OECD countries in the field of math, our students came in twenty-sixth, belo such countries as Liechtenstein, Iceland, and the Czech Republic.[5] Over and over again, the places th come in at the top? Shanghai, Singapore, Taiwan, South Korea, and Japan. Upon the release of the rankings and scores, the *Wall Street Journal* editorialized: "Perhaps most depressingly, the data sho no statistically significant U.S. achievement improvement over time. None. In an era when it pays be thankful for small mercies, at least we're not getting worse, but America's relative standing falling as other countries improve."[6]

While every test has its critics, the OECD test, known as the "Program for International Stude Assessment" (or PISA), is highly respected. U.S. Secretary of Education Arne Duncan said of t results from the 2009 test, which showed results similar to those of the 2012 test, "We can quibble, we can face the brutal truth that we're being out-educated."[7] Secretary Duncan is right, but he could

further. We are being out-educated because we are simply not realizing our potential. We are a natio under-taught and under-educated. The fault is ours.

When it comes to our own scores at home, the news looks even worse. NAEP, as mentioned abov measures our students in a variety of subjects at different grade levels; it is administered to hundre of thousands of students in America and is known as "the gold standard" of testing. Almost a education experts hold it in high regard.[8] In the most recent assessment of fourth and eighth grade released in 2013, we found that only thirty-four percent of our nation's fourth graders we "proficient" at math—that is, they were at an achievement level one would think of as "competent" higher—and seventeen percent were "below basic" in their mathematics abilities. In other word almost one out of five fourth graders were failing math.[9] By eighth grade, the numbers were eve worse: twenty-seven percent of our nation's eighth graders were performing at the proficient lev while a full twenty-six percent were scoring below basic, or failing.[10] By high school, as we sa above, the numbers were worse yet.[11]

Given all the resources we have at our disposal today, given all the money we pour into scho systems (over $600 billon a year in America in elementary and secondary education funding alon and into studies on how to educate, it is nothing short of tragic that a majority of our nation's studen score below a standard of competence, or proficient. Looking at the trend where fourth graders sco better than eighth graders, who score better than twelfth graders, former U.S. Secretary of Educatio and Project Lead The Way (PLTW) Senior Advisor William J. Bennett observes: "The longer on stays in school in America, the worse one does."[12]

When it comes to science education, we do dismally as well. In fourth grade, the latest NAEP score (from 2009) show a thirty-four percent proficiency rate and a twenty-eight percent failure rate.[13] eighth grade, the most recent NAEP (from 2011) reveals thirty-two percent of our students scorin proficiently and thirty-five percent failing.[14] And our twelfth graders? The most recent assessment fo them (2009) shows a twenty-one percent proficiency rate and a full forty percent failure rate[15]—wor than they do in math and, still, an upside-down trajectory where the longer students stay in school, th worse they perform.

The state of our STEM education does not have to be this way, but more importantly, it cannot sta this way. The good news is, while there is rampant failure and mediocrity throughout our nation education system, there are great examples where this is simply not happening, where success is th norm. However, if America is going to remain the—or just a—leading nation, we must ignite a fiero urgency throughout our nation's education system. We must move from pockets of excellence to system of excellence.

To highlight the need for this fierce urgency, we only need go to the most recent White House repo from the President's Council of Advisors on Science and Technology (or PCAST). The President Council opened its February 2012 report stating, "Economic projections point to a need f approximately one million more STEM professionals than the U.S. will produce at the current ra over the next decade if the country is to retain its historical preeminence in science and technolog To meet this goal, the United States will need to increase the number of students who receiv undergraduate STEM degrees by about thirty-four percent annually over current rates."[16] We are no on course to do this - not at the elementary, secondary, or post-secondary levels of education.

This is a challenging proposition given our students' lack of interest and poor performance science and math. A recent report suggested that about twenty-eight percent of high school freshm (one million high school students) declare an interest in STEM-related fields each year, but som fifty-seven percent of them will lose interest over the course of their high school careers.[17] We los about 570,000 STEM-eager high school students each year by their senior year in high school. We ar turning off over half a million brains to the fields of math and science in high school alone…eve

year!

And, nowhere near a majority of high school students are even competent in subjects like math an science, never mind advanced. Only three percent of our nation's high school seniors score at a "advanced" level in math on the NAEP test,[18] while only one percent of our nation's high scho seniors score at an "advanced" level in science.[19] A portion of these are the students who most likel will go on to attain graduate degrees in those fields, attend the best colleges and universities in tho fields, and ultimately go on to become leaders in their fields in academics, medicine, research, industry. One recent report puts that portion at about seventeen percent![20]

So, by the time we have high school seniors competent in science and math, and still interested STEM fields and careers, we have a woefully inadequate pool or pipeline. Then they get to colleg And there, less than forty percent of college students who enter college intent on a degree in th STEM fields stay on course and graduate with that STEM degree.[21] We lose students' interest in hig school if we were fortunate enough to have encouraged those students in elementary and midd school in the first place; and then of those who stay interested, we lose a majority of them in college.

We simply cannot go on this way, not if the serious reports on the future needs of this country are be taken seriously, and they should be. The current STEM workforce is about 7.4 million employe with an estimated 8.6 million employees needed by 2018.[22] And that is just a minimum projectio America cannot win by simply maintaining the number of students who pursue STEM-related degree we need to inspire over one million more, and that is just to stay the course with the current econom But, we are not on that trajectory. We are nowhere near it.

The American Economy of Today and Tomorrow—Still the Last Bes Hope?

Abraham Lincoln famously declared the United States "the last, best hope of earth." Other leade have said much the same in the past. Ronald Reagan put his twist on it by calling us "the last, be hope of man on earth."[23] The Russian human rights hero and Nobel laureate Aleksandr Solzhenitsy said, "The United States of America has long shown itself to be the most magnanimous, the mo generous country in the world."[24] And in his time, the novelist Thomas Wolfe said America "is fabulous country, the only fabulous country; it is the only place where miracles not only happen, b where they happen all the time."[25] I could go on and on with these kinds of quotes about America greatness. But what all the giants of leadership and letters were testifying to was not just our nation political philosophy, dedicated to liberty and equality as it was and is. They were speaking to th significance of the equal opportunity and freedom that had led us and the world, in their time an before, and could continue to lead us in the future. This notion of "best hope," or greatness of nation and international leadership, of exceptionalism, can only continue to apply and abide if America is remain an economic powerhouse—if it continues to be a place of industry, financial strength, growt employment, startups, innovation, and entrepreneurship.

But the fundamentals of our economy today are not strong; indeed, they bode serious trouble an concern. Let us take a look at the landscape of our recent recession and state of economic affairs. Mo people over the age of fifty can remember the 1970s, or what is loosely referred to as the "Cart years," as a time of economic hardship and failure. The standard line that then-governor Rona Reagan used in talking about unemployment in his campaign against President Jimmy Carter in tho years was: "A recession is when your neighbor loses his job. A depression is when you lose yours. An recovery is when Jimmy Carter loses his."[26] Ronald Reagan got a lot of mileage out of that line. B for as bad as our economy and the state of unemployment was in those years, the numbers are almo enviable when contrasted to today.[27]

The highest unemployment rate in the Carter years, the late 1970s, was 7.5 percent and by 197 unemployment was in the five-percent-to-six-percent range.[28] When the American economy went int free-fall in 2008—President George W. Bush's last year in office—and the presidential campaig became so much about the economy, unemployment was heading toward seven percent again (after had been in the four-percent- and five-percent-range for many of the previous years).[29] Whe President Barack Obama took office in 2009, unemployment was already at 7.8 percent and wou surge up to eight, nine, and then ten percent.[30]

When the "Recovery Summer" was declared by the Obama administration in 2010, unemployme was still over nine percent. Through the summer of 2013, America was showing the worst GDP grow rate for a full fifteen quarters since World War II. [31] And today, with a rate still over six percent, man do not believe this is the real unemployment rate, given how many Americans are underemployed have simply stopped looking for work. Some have argued the real unemployment rate may be as hig as fourteen percent or greater.[32] This is double the rate than when most Americans thought th economy was in terrible shape.

Other fundamentals today reveal an equally worrisome landscape. Our economic growth, measure in Gross Domestic Product (or GDP), stood at about 2.3 percent over the last few years.[33] While that better than no growth, or "negative growth," it is still an anemic number. By contrast, in the 1950

there were years with seven percent and eight percent growth; in the 1960s we had years with fi percent and six percent growth, in the 1970s and 1980s, we had years with over five percent a sometimes seven percent growth, but now we are lucky to get up to 2.3 percent GDP growth.[34] And, recently as June of 2014, the *Wall Street Journal* had this headline: "U.S. Economy Shrinks by Mo in Five Years."[35] Yes, with all the talk of "recovery," indeed it truly runs weak to sporadic with o step forward and two steps back. To give a little more of an idea on how this is occurring, here's mo from the story:

> Gross domestic product, the broadest measure of goods and services produced across the economy, fell at a seasonally adjusted annual rate of 2.9% in the first quarter, the Commerce Department said in its third reading of the data Wednesday.
>
> That was a sharp downward revision from the previous estimate that output fell at an annual rate of 1%. It also represented the fastest rate of decline since the recession, and was the largest drop recorded since the end of World War II that wasn't part of a recession.[36]

Growth is what both encourages and indicates innovation and overall economic health. We simp are not healthy today. Indeed, we are, as of this writing, in the summer of 2014, just coming out of first quarter contraction![37] I fear we may be forgetting what "healthy" looks and feels like.

This is all much more than troubling. Take a look at our average high school or college senio Assuming high school or college graduation in the first place (which is a topic of concern I w address later): What are our seniors' job prospects? What are his or her opportunities? While today student debt is at an all-time high, surpassing one trillion dollars, with many struggling to pay off th debt, many believe that number alone could constitute the next economic bubble to burst.[38] But t outlook was discouraging for 2013 graduates. A Google scan of news headlines: "College Gra Overconfident in Job Prospects,"[39] "Job Picture Looks Bleak for 2013 College Grads,"[40] "The Class 2013: Young Graduates Still Face Dim Job Prospects,"[41] "Half of College Grads Can't Find Full-tim Work…"[42] And these headlines came as the 2013 market was actually better than the 2012 market.

Where, however, is there a potential bright spot? According to a report by the National Associatio of Colleges and Employers, "employment areas with the greatest demand for this year's graduat include business, engineering, computer sciences and accounting."[43] But this is only a potential brig spot because while there is demand, there is not supply:

> A survey of 500 hiring managers by recruitment firm Adecco, found that a majority—66 percent—believe new college graduates are not prepared for the workforce after leaving college. Fifty-eight percent said they were not planning to hire entry-level graduates this year, and among those managers hiring, 69 percent said they plan to bring on only one or two candidates.
>
> "Too many students are graduating with a weak background in science and math," said Mauri Ditzler, president of Monmouth College.
>
> "We need to make sure our graduates know the basics and many don't."[44]

Graduates do not know the basics in the areas where there is and will be actual job growth a demand. And those are the "graduates." The drop-outs have an even poorer shot at the America dream, a sad commentary given that we have a forty-three percent college graduation rate in Americ placing us eleventh among the OECD list of countries.[45] As for high school graduation? One millio high school students a year drop out, "a loss of 5,500 students for every day on the academ calendar."[46]

There is a healthy, ongoing debate in our country about the actual economic worth of a colle education, and many of my friends and colleagues have important and diverse views on the subje But, three things are indisputable: 1) high school completion is simply not enough; 2) if you want

dramatically increase your options for gainful and sustainable employment—even in a down econom with bleak job prospects—the odds are heavily tilted toward those with a college or advanced degre and, 3) the types of skills, knowledge, and degrees matter.

The odds are simply better with degrees in "business, engineering, computer sciences, ar accounting," or what many call or label "the hard sciences." Even most of my friends who questio the worth of college education do not question it in those fields or for those who go to top college The entrepreneurial geniuses Bill Gates and Steve Jobs, who dropped out of college to create va empires, are the rare exceptions. As William Bennett and David Wilezol stated in *Is College Wort It?*, "If you are accepted into the Colorado School of Mines, Harvey Mudd, Stanford, Plan II at th University of Texas, and dozens of other places…then go. And if you want to study petroleu engineering or any kind of engineering and have an aptitude for it, then go."[47]

But therein lies the problem: aptitude. Not enough of our high school students are ready or eve interested in post-secondary education like that. There is a reason, after all, that so many high tec companies and chambers of commerce want to expand the number of H1B visas granted every year America. The H1B visa is the high-skilled non-immigrant work visa, especially common in the are of engineering and math.[48] So badly are these workers needed that one recent report found that "in th absence of green cards and H1B visa constraints in the 2003-07 period, roughly 182,000 foreig graduates of U.S. colleges and universities would likely have remained in the country and raised th gross domestic product (GDP) by roughly $13.6 billion."[49] By the way, the vast majority of the H1 visas go to students from Asia, mostly China and Korea—no great surprise given the numbers presented in the opening of this book.[50] More than half of the science and engineering graduat working in America today are from other countries.[51]

Of the nearly 1.8 million bachelor degrees awarded in America each year, only about one-third a in STEM-related fields, while a majority of China's bachelor degrees and over sixty percent Japan's bachelor degrees are in those fields.[52] "South Korea graduates more engineers than the Unite States…and in many Asian countries, 21 percent of college graduates are engineers, compared to 1 percent in Europe and 4.5 percent in the United States," reported Charles Vest, president of th National Academy of Engineering and MIT president emeritus.[53]

I write "so badly are these workers needed," above because of reports just like this one, showin that we simply are not raising our own graduates able to take these jobs and boost our GDP. I suppo expanding the H1B visa program, but I do so knowing the tragedy of the decision: we do not train o own students well enough to take these jobs and raise our GDP. In other words, it is both a shame an a necessity that we have to import talent. I am, however, an optimist, supporting the expanded vis program on a temporary basis, because I firmly believe we can reverse course and, in fact, "grow o own." Indeed, I know that if we are to remain the last best hope of earth, we have no other choice. W cannot survive on temporary and imported talent forever, we cannot consign our own citizens an children to average and less than average educations any longer, and certainly not at the same tim other nations are beating us.

This is not just a matter of education for education's sake or for the mere desire and preference th we employ our own citizens while unemployment is high instead of having to import from oth countries the talent our own corporations need. No. This is about staying competitive in the glob economy and not allowing any country to beat us as an economic and education engine or powerhous I am not an expert in international economics or in international relations, nor is this book focused o those topics, but it does not take such an expert to tell us that we need to be concerned about our ov economy for our own sake, and that we need to be concerned about our competition.

I believe it is fair to say that the last several presidential administrations—both Republican an Democratic—have viewed China as an economic competitor and certainly a large portion of the wor

does as well. A recent Pew Global Attitudes survey found, for instance, that "53 percent in Britain sa China is the leading economy, while 33 percent name the U.S. In Germany, 59 percent say Chi occupies the top place, while only 19 percent think the U.S is the global economic leader."[54] And her in America? What do we think of ourselves? We are not so sure, but we are thinking less and less ourselves compared to China: "Americans are divided, with 47 percent saying that China has or wi replace the U.S. and 47 percent saying this will never happen. That is a significant shift of U.S. publ opinion from 2008 when only 36 percent said China would become the top global power and 5 percent said China would never replace the U.S."[55]

One can certainly make the case, as many have, that China's days as an economic powerhouse a numbered for several reasons. But there are a few indisputable facts that still remain, aside fro China's education prowess and achievements (especially as compared to our own): The Chine economy is the second largest in the world, and as one economic respondent to the prognosticators China's collapse put it:

> [W]hile China's economy may slow to less than the 8-10 percent growth it normally averages, a real collapse, to growth rates of 2 percent or 3 percent, or less, is highly unlikely. For one, China's state and private companies may be getting too easy credit from state banks, but that does not mean these businesses are actually unproductive, like some of the Thai and Indonesian companies caught up in the 1997 Asian finance crisis. The truly unproductive Chinese state-owned and state-linked enterprises were closed down more than a decade ago.…

Meanwhile:

> Chinese companies alone, nearly all of them state-owned, occupied 73 of the top 500 slots in Fortune's 2012 ranking of the largest companies in the world by sales. China's score has steadily risen on the Global Competitiveness Index; the World Economic Forum's ranking of nations' international economic competitiveness. And several Chinese companies, such as Huawei, have come to dominate global markets like telecommunications.[56]

As of this writing, China's economic growth rate has, indeed, slowed, to between 7.4 and 7 percent. The United States is stuck at about 2.8 percent growth, on average, over the past few yea with very little prospect of the optimists' hope that we reach an annual three percent growth by th end 2014.[57] As for their education condition, education expert Chester E. Finn, Jr., said this aft seeing China's international rankings in reading, math, and science: "Wow, I'm kind of stunned.. I've seen how relentless the Chinese are at accomplishing goals, and if they can do this in Shanghai 2009, they can do it in 10 cities in 2019, and in 50 cities by 2029."[58] In all my travels throughо America, and having visited hundreds of schools, I have never heard an American education offici look at a successful system in America and say without a doubt that we can replicate such success fifty cities (too often, I do hear reasons why isolated examples of success are not replicable). It is m proposal and theory, however, that we can replicate success. I certainly know we must.

With over $600 billion a year invested in public elementary and secondary education,[59] Americar spend more than any other developed nation on its K-12 school students.[60] But we are falling behir too many of those other nations—investing money in programs that add little or no value and n appropriately educating our youth. Why do other countries, particularly Asian countries in the STE fields, continually beat us? The reasons are myriad…but, I'm convinced the solutions are not. I hav the privilege to see how rigorous programs in STEM education can transform not only student minds, but our educational landscape as well—from theory to action. We just need to take what v know works to scale.

It is in the STEM fields where that need is most urgent. That is where the growth and opportuniti are. It is also where our international counterparts are most seriously beating us. But do not just tal my word for it. The Nobel Prize-winning economist Robert Solow has pointed out that half th economic growth in America since World War II has come from advances in science ar

technology.[61] Susan Hockfield, President of the Massachusetts Institute of Technology (MIT), mad two key points on this recently: Asking, "What can we do, together, to restart America's job-creatio machine?" she said,

> I believe the answer lies in retooling the engine that has driven wave after wave of economic growth since the end of World War II: America's innovation system.…Our innovation system comes to life from the spark of scientific discovery and invention — but the kind of innovation that drives real economic growth goes beyond a cool idea or an incremental improvement on an old practice or product. We're driving for innovations that produce big new ideas, based in science or technology, that can be transformed into market-ready products. Innovations that can create new markets — sometimes even new industries — and that create a future different from, and better than, the present.[62]

She also warned us about our ability to deliver on those innovations: "If we want to make U.S. job we can't just make ideas here — we have to make the products here. Unfortunately, no amount innovation will be enough if we ship all of our manufacturing abroad. America remains the world second-largest manufacturer, but with so many nations copying our innovation model, we must stak our bets on the kind of advanced manufacturing the future demands."[63] This statement, alone, haun me as I digest all that has gone wrong with the city of Detroit, once known not only as the automobi manufacturing capital of the world but once even as the "Capital of the 20th Century." Today it i literally, bankrupt. I believe, however, if Detroit's bankruptcy is to be overcome, it will be overcon by innovation and growth such as what GM has done to turn itself around from bankruptcy, and n simply because of government investment.[64] In fact, speaking of his company's resurgence, form GM CEO Dan Akerson responded to a congressional delegation, "no, we're fine," when asked Washington should provide more help.[65]

Others, from industry, have weighed in on the importance of STEM as well. Fred Smith, th Founder and Chairman of FedEx has stated, "I personally think that the federal government—an you're talking to a liberal arts major here—should restrict its funding of higher-education grants an loans to science, math, and engineering because that's where most of the value added comes." Rodney C. Adkins, a senior vice president at IBM has written, "When I graduated from college [circ 1978], about 40% of the world's scientists and engineers resided in the U.S. Today that number ha shrunk to about 15%."[67] Antonio Perez, chairman and CEO of Eastman Kodak put it this way: "Th American economy has always depended on innovation, and in a knowledge-based society, there ca be no real innovation without an educational emphasis on science, technology, engineering and mat This is especially important to create a workforce that can succeed in today's rapidly changin economy."[68]

I could go on and on with a list of quotes along these lines. But, there is a reason dozens corporate leaders in America, from companies as diverse as Chevron, Lockheed Martin, Do Chemical, Eli Lilly, GE, and Facebook have formed Change the Equation, a "CEO-led initiative that mobilizing the business community to improve the quality of science, technology, engineering an mathematics learning in the United States."[69] This is a critically important organization helping sour the clarion call and proposing solutions to our STEM education problems in America. Change th Equation, led by Linda Rosen, recently endorsed four high quality and nationally scalab organizations: Project Lead The Way, Gilstart Summer Camp, ST Math, and Ten80 Student Racin Challenge. We ignore its work at our peril. I encourage every reader of this book to check out i website.

But, for now, to highlight as simply as possible the economic challenge and opportunity we fa with STEM education, let me go to a recent report from PCAST. The report is essential readin "Throughout the 20th century, the U.S. education system drove much of our Nation's economic growt and prosperity," the Council states.[70] Obvious enough. And if not obvious enough, it states what I hav

been trying to highlight in this chapter: “Despite our historical record of achievement, the Unite States now lags behind other nations in STEM education at the elementary and secondary levels. Ov the past several decades, a variety of indicators have made clear that we are failing to educate many our young people to compete in an increasingly high-tech global economy and to contribute national goals.”[71]

STEM is where the growth is needed and STEM is where our economic growth is. As the Chancell of the University of Wisconsin-Madison, Rebecca Blank, posited when she was working in th Department of Commerce, “STEM workers earn a premium of 25 percent over other workers and hav only a 5.5 percent unemployment rate.”[72] These numbers are backed up by other reports, including recent one by the National Governors’ Association, which further pointed out that while the 5 percent unemployment rate applied to STEM workers, it hit ten percent at the same time for no STEM workers.[73] In fact, the chances of one being unemployed in a STEM field are exceedingly ra as STEM job postings actually outnumber unemployed people.[74]

William Bennett and David Wilezol point out why this is; and while it may say something goo about interest in some of the humanities and liberal arts fields, the basic realities of the economy tell different tale: “Too many students gravitate toward majors in which they gain few skills or for whic there is little workplace demand.”[75] I will later go into some of the reasons why there is a crisis in o major fields of studies, but first it is worth pointing out that while total college enrollment has risc some fifty percent since 1985, in fields such as math and statistics the numbers have hardly move from 15,009 college graduates in those fields in 1985 to 15,496 in 2009.[76] And in the fields “microbiology, chemical engineering, and computer science, we graduated more students in tho fields in 1985 than we do today.”[77] Finally, more students graduate with college degrees in the visu and performing arts than in “computer science, math, and chemical engineering combined.”[78] paying off student debt, raising a family, or just supporting oneself is a concern of college student this statistic should close the discussion: of the top twenty majors with the highest midcareer salarie “all but one (economics) are STEM disciplines.”[79] And I would include economics in the STE category.

Let me provide some starker statistics to highlight the broken pipeline to the foregone possibilitie the missed American Dream if you will: Engineering degrees constitute about 4.7 percent of bachelo degrees awarded each year, and that is down from seven and eight percent in those fields two and thr decades ago, which was already a pretty small percentage.[80] Computer science degrees constitute le than three percent of bachelors degrees, never having risen above five percent in the last forty years Biology? 3.7 percent.[82] Chemistry? Less than one percent.[83] Math? Just over one percent.[84] But th fields of psychology, art and performance, and education each routinely more than double th percentages of computer science degrees we award each year. We graduate four hundred percent mo art and performance students from college each year than we do computer scientists—and fiv hundred percent more art and performance students than math students.

Meanwhile, a closer look at STEM readiness and preparedness in our students and workforce show what it can mean for the country’s growth as a whole.

The National Governors’ Association report makes a point worth quoting at length:

> According to the Milken Institute’s Best-Performing Cities 2010, “A rich innovation pipeline plays a pivotal role in a region’s industrial development, commercialization, competitiveness, and ability to sustain long-term growth.” The STEM workforce is a powerful component of this innovation pipeline. STEM occupations employ individuals who create ideas and applications that become commercialized and yield additional jobs. STEM fields overwhelmingly dominate other fields in generating new patents, including those that enter the marketplace. For example, during 1998–2003, scientists and engineers (S&E) applied for nearly 10 times more patents and commercialized almost eight times more patents than applicants from all other fields.

> STEM workers also contribute to the creation of innovation hubs—areas that usually include technology centers and research parks—that are important sources of economic activity. STEM workers are often found in high concentrations in these areas. In addition, research universities and other postsecondary institutions typically are nearby, providing new supplies of STEM graduates and opportunities for collaboration. Innovation hubs can spawn clusters of associated businesses and suppliers in both STEM and non-STEM fields while also rapidly growing jobs.[85]

And, as the U.S. Department of Commerce tells us, "The greatest advancements in our society fro medicine to mechanics have come from the minds of those interested in or studied in the areas STEM. Although still relatively small in number, the STEM workforce has an outsized impact on nation's competitiveness, economic growth, and overall standard of living."[86]

What would raising our proficiency in math and science mean to the economy and growth America? Various studies show a variety of results, but all reach the same conclusion: More growth. lot more. According to a report by the National Governors' Association, the Council of Chief Sta School Officers, and Achieve, Inc., "If the United States raised students' math and science to globall competitive levels over the next two decades, its GDP would be an additional 36 percent higher 7 years from now."[87] More recently, McKinsey & Co. found that, "At the K–12 level, enhancin classroom instruction, turning around underperforming high schools, and introducing digital learnin tools can boost student achievement. These initiatives could raise GDP by as much as $265 billion b 2020—and achieve a dramatic "liftoff" effect by 2030, adding as much as $1.7 trillion to annu GDP." That is greater than our current national budget deficit. Add the concept of reforming ou teacher workforce by just five to seven percent, and we have not only erased our budgetary concern we will put America back into budget surpluses.

I know the excuses – students in the United States are more creative, better problem-solvers tha students from other nations who excel in rote learning and test-taking. So in 2012, PISA teste problem-solving for the first time. How did we do? We scored about average, still behind Kore China, and other nations. Then there is the excuse that other countries are vastly different than our culturally and in a great many other ways. So, compare Canada. As Standford's Eric Hanushe Harvard's Paul Peterson, and University of Munich's Ludger Woessmann recently pointed out in the book *Endangering Prosperity*, while the United States falls below most industrialized countries international comparisons of mathematics achievement and proficiency of its 15-year-olds, it beaten handily by Canada which is ranked 10th in the world (the United States is ranked 32nd). B Canada is not that culturally different from the United States: "the two countries share a commo language, a common heritage, and a common border."[88] As Hanushek points out elsewhere, "Canad also has an influx of immigrants; they have strong unions; it's a federalist system."[89] But look at wh it would mean for our economy if we could simply achieve what Canada achieves in its level educational performance by 2025, giving us a little more than a decade to get there: "The averag annual income of every worker in the United States over the next 80 years would be 20 percent highe …the gains from a faster-growing economy over the lifetime of somebody born today would amou to five times our current GDP [some $77 trillion]…enough to resolve the projected U.S. debt crisis."

Let me explain some of this from a personal standpoint. I'm often asked why science, technolog engineering and math are the only words used to create the acronym, and when Project Lead The Wa (PLTW), the STEM organization I am proud to lead, will change STEM to STEAM, STREAM STEMM—incorporating art, reading or music into the acronym. This misses the fundamental poin Our societal, economic, and education problems are not anywhere near or about adding to acronym but instead adding to the relevancy of learning. Our solutions are about showing students ho technical concepts relate to real-world situations and providing them with hands-on projects an problems that help them apply concepts in ever-new and changing contexts. It's about nurturin students' curiosity and helping them develop creativity, problem solving, critical thinking, an

collaboration skills. STEM isn't simply the subjects in the acronym. It's an engaging and exciting wa
of teaching and learning. Or should be. And can be.

On a recent flight to a speaking engagement in California, I had a conversation with the perso
sitting next to me. She asked me what I did, and when I told her, she remarked, "Oh, you're one
those." When I asked what she did, she explained that she was the creative director for an advertisi
agency, and the world of STEM seems to disregard, even dismiss, the arts. Moments later, she bega
working on her MacBook Pro, loaded with state-of-the-art software. So my question to her was "Wh
do you think made that laptop and developed the software for artists and creators like you?" STE
fields are at the core of everything we do. STEM connects to everything, whether it is the arts, musi
sports or agriculture.

Look no further than the materials and technology artists use: computers and graphics, paint,
canvas. Computer scientists develop the graphics technology, chemists work to ensure the rig
chemical composition to create vibrant colors, and engineers design a stronger canvas that absorbs th
right amount of paint. Furthermore, the same creativity that inspires beautiful works of art is the san
creativity that has led to some of the world's highest-performing, usable and visually appealin
inventions. For instance, the Corvette Stingray, the 2014 North American Car of the Year, is a
engineering marvel and one of the top-performing automobiles on the market. But, it's als
aesthetically appealing. The same could be said for your new lightweight running shoes, your singl
serving coffee maker, or the acoustically designed facilities for your community's symphon
orchestra. These are all examples of engineering and the arts working together, and they all result
from the same design process engineers use to build the world's most advanced fighter jets, develo
new energy solutions, and create targeted therapies for chronic diseases.

STEM can be found in virtually every discipline and in every product. STEM is not exclusive to th
subjects of science, technology, engineering, or math. We must continue engaging students in th
STEM disciplines and encouraging them to combine technical knowledge and skills with the creativi
that leads to innovative ideas—ideas that give the arts new technologies, music new instrument
farmers new machines, and our businesses a competitive advantage. Unless we continue building th
STEM pipeline, each profession suffers. We end up encouraging the end product of art an
performance while discouraging or neglecting science, technology, engineering, and math.

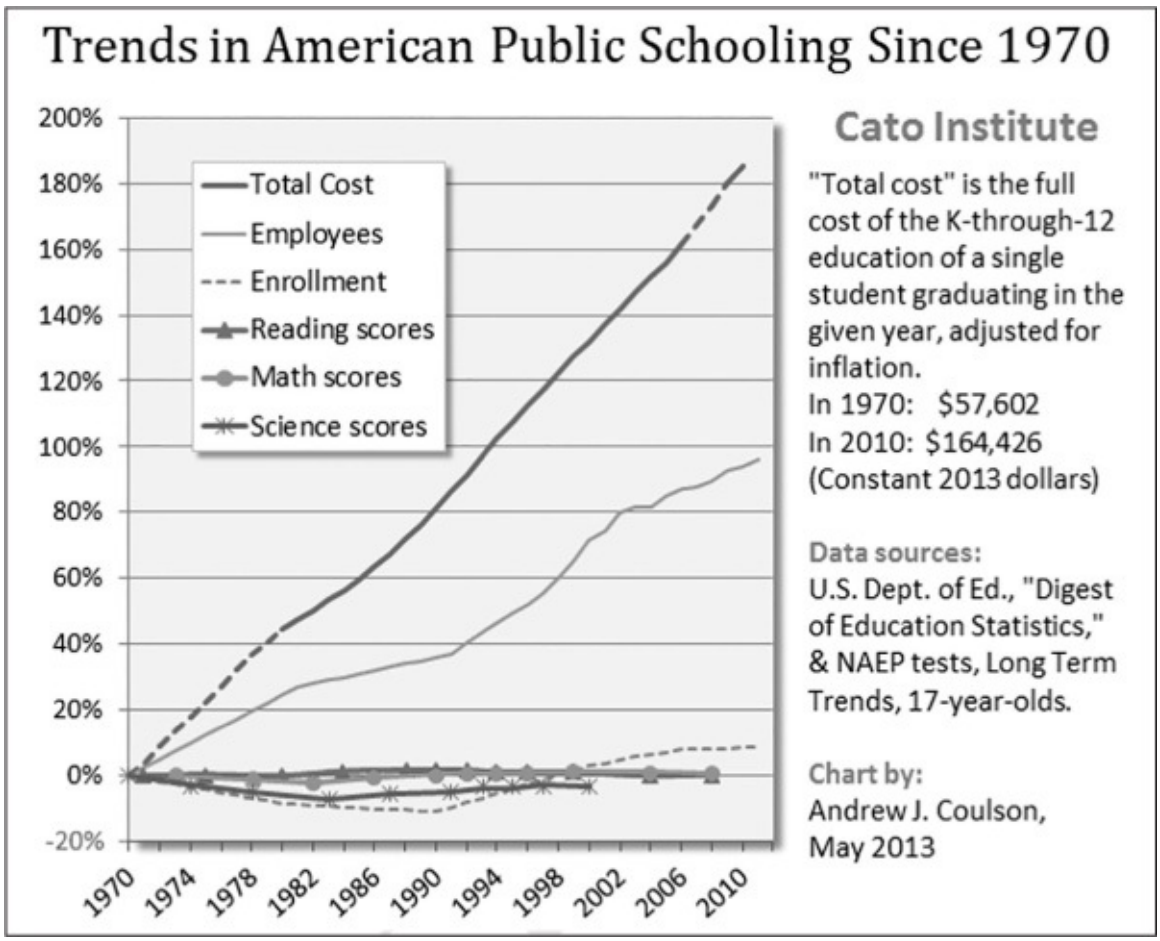
That is why education reform generally, and STEM education specifically, are the keys to o
economic well-being and future.

Why We Fail & How To Fix It

It has been a full generation—thirty years—since the landmark "Nation at Risk" report was issued b the U.S. Department of Education. That report opened with this ominous warning: "Our Nation is risk. Our once unchallenged preeminence in commerce, industry, science, and technologic innovation is being overtaken by competitors throughout the world."[91] To add to the drama of th problem, the report's authors continued:

> If an unfriendly foreign power had attempted to impose on America the mediocre educational performance that exists today, we might well have viewed it as an act of war. As it stands, we have allowed this to happen to ourselves. We have even squandered the gains in student achievement made in the wake of the Sputnik challenge. Moreover, we have dismantled essential support systems which helped make those gains possible. We have, in effect, been committing an act of unthinking, unilateral educational disarmament.[92]

Since then, there have been any number of citations to the Nation at Risk, there have been an number of education reform proposals, we have overhauled testing regimens, and added billions dollars into our education system. But the results over the past thirty years have been flat at best, wi no appreciable change upward in our scores. I say "at best," because in many ways we have don worse. This chart of national expenditures and scores from 1970 to 2010 explains just about the who story:



Spending went up, educational hires from teachers to administrators increased, and scores have fla lined. The point is, we still do not get it right in American education: not in reading, not in writin

and not in the STEM fields. And, as stated earlier, we are spending more than other countries that d
get it right. What is the problem? And why is it so hard to see and overcome?

The answers to these questions are partly pedagogical and partly cultural. Let me start with th
pedagogical. In looking at the other countries whose students continually outmatch our students in th
STEM fields, there is the answer of time. Other nations, especially the ones that beat us, simply p
their students through more schooling. As education reform expert Chester E. Finn, Jr. put it recently

> Schoolchildren in China attend school 41 days a year more than most young Americans—and receive 30% more hours of instruction. Schools in Singapore operate 40 weeks a year. Saturday classes are the norm in Korea and other Asian countries—and Japanese authorities are having second thoughts about their 1998 decision to cease Saturday-morning instruction. This additional time spent learning is one big reason that youngsters from many Asian nations routinely out-score their American counterparts on international tests of science and math.[93]

Our students' "summer learning loss" is "no joke," Finn writes, as our students lose "a full month
worth [over the summer], by most estimates, adding up to 1.3 school years by the end of hig
school."[94] And then there is this: "students in other postindustrial countries receive twice as muc
instruction in core academic areas during high school."[95]

Take the issue of summer recess/break and summer learning for a moment. At a time when there
so much focus on American students' global education competitiveness, students and teachers at a
grade levels should find opportunities to keep their minds active and continue learning while enjoyin
our vaunted and nearly-sacrosanct summer breaks. I am not against them, not at all. Our teachers nee
them, our principals need them, our parents and children need them.

But, still, summer learning loss is real. It is also counterproductive, requiring teachers to spen
considerable time at the beginning of the new school year reviewing before they introduce ne
material and help students develop new and advanced skills. The National Summer Learnin
Association reports that students lose an equivalent of two months of their grade-level ma
computational skills over the summer, and students from low-income families also lose the sam
equivalency in reading achievement. While summer is a time to relax, it is not a time to stop learning

The key to education—especially in critical STEM fields—is activity-based learning that mak
concepts relevant in real-world, meaningful ways. In Project Lead The Way classroom curriculum, f
example, velocity, speed, lift, and drag—concepts often taught in a high school physics class—a
applied when building an airfoil that must meet certain constraints. In third grade, students learn abo
forces, axels and levers, and apply these concepts to design a simple machine to rescue an animal th
has fallen into a trench. Lessons like these show students the relevancy of their learning and engag
and inspire them to continue learning. But learning like this doesn't have to be confined to
classroom. Nor should it all be lost over the course of two and a half to three months.

While traditional summer school is beneficial for some students, summer learning does not have
mean spending all day inside a classroom or library. Summer activities are rife with real-wor
learning experiences that parents and communities can help convey: A swimming pool can teac
students about buoyancy. The ocean waves can be a lesson in gravitational forces. A baseball gam
can teach about velocity and drag. Parents and children who enjoy baking together can turn th
measurements into a math lesson on fractions. There are websites and apps, sites like Kahn Academ
and PBS' Design Squad, that provide engaging lessons and activities for kids. Many tools can b
accessed at a community library if a computer is not available in the home. Parents can also take tim
to encourage their child to read, helping build not only reading comprehension and vocabulary skill
but also knowledge on topics that students find interesting.

Summer camps are another great way to continue student learning. Organizations like Boy Scout
Girl Scouts, Boys and Girls Clubs of America, 4H, and local zoos or museums offer exciting ar

engaging opportunities for students. Project Lead The Way partners with the Society of Manufacturi Engineers Education Foundation to support Gateway Academy camps across the United States. Th past summer, nearly 5,000 middle school students spent a week immersed in hands-on activiti building knowledge on topics like programming, alternative energy, flight and space, fluid power, ar the engineering design process.

Summer is also a terrific time for teachers to improve their craft by engaging in profession development—not the kind of professional development that teaches the latest fads in education, b rather the kind that focuses on how teachers can engage students in relevant learning. Continuo teacher training and learning is vital to student success. A number of universities offer formal summ courses. Nonprofit organizations like Project Lead The Way offer rigorous, in-depth resident trainir programs. And while Massive Open Online Courses (MOOCs) have their supporters and opponents, MOOC could be a great option for continuous teacher learning over the summer months.

Learning does not have to cease for the summer when the last class bell rings. Students, teache and parents can have an enjoyable and relaxing summer, all while continuing the education proces The responsibility to continue learning during the summer rests with each one of us. When it comes summer learning loss, we can change course. We can continuously improve, learn and engage, ar have a great summer in the process.

We also must address the growing concern—more and more appreciated over the past few years- emphasizing teacher quality and compensation. As Michael Milken put it:

> Once upon a time, U.S. college graduates near the top of their classes routinely entered the teaching profession. In fact, 90 percent of new American teachers in the early to mid-20th century came from the upper third of their classes. Today, it's just 23 percent. Meanwhile, virtually 100 percent of teachers in Singapore, South Korea and Finland come from the top third of their graduating classes.[96]

And we now know that teacher quality is, after parent involvement, the single greatest factor in child's education. As Microsoft Founder Bill Gates has said, "the single most decisive factor student achievement is excellent teaching. It is astonishing what great teachers can do for the students."[97] William Bennett cites two graphic studies that tell the whole tale:

> [I]f you take an 8-year-old student performing at the 50th percentile and give him a low-performing teacher, he will regress to the 37th percentile in three years. Give him a high-performing teacher, and he will succeed to the 90th percentile in the same amount of time—a swing of 53 percentage points.[98]

And,

> According to an analysis by Stanford economist Eric Hanushek, if you replaced the lowest-performing teachers in our country (roughly 5% to 10% of the teaching work force) with just average performing teachers, America's students as a whole would rise from the bottom of the performance ladder on international tests to a Top 10 ranking. What would this mean for our GDP, by the way? Tens of trillions of dollars.[99]

A recent McKinsey study backs up an important element of this as well: the professionalism ar skills of our teacher workforce. Comparing us to countries like Finland, Singapore, and South Korea- countries that continually beat us—McKinsey has found: "The U.S. does not take a strategic systematic approach to nurturing teaching talent. Buffeted by a chaotic mix of labor market trend university economics, and local school district and budget dynamics, we have failed to attrac develop, reward or retain outstanding professional teaching talent on a consistent basis."[100] Tho countries, "recruit, develop and retain…'top third' students as one of their central educatio strategies, and they've achieved extraordinary results. These systems recruit 100% of their teach corps from the top third of the academic cohort, and then screen for other important qualities as wel