

1997 Distinguished Teacher of the Year

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The World Needs More Nerds

President Catanese, Provost Osburn, FAU faculty and staff, FAU students, and guests: This award is an honor. There are many faculty deserving of it and I accept it on their behalf as well as mine – but I’m going to keep the money. The recognition is especially cherished because it comes from the students. Students are our reason for being here; there is no better source of praise.

Rarely does a faculty member get an opportunity to speak at such a forum. I thought a long time about what I wanted to say today about the state of higher education, so please take my comments as sincere even if you disagree with me. If nothing more, I hope my remarks will kindle a needed debate.

I have a confession: I’m a nerd. I’m not a nerd by design, but I am certainly a nerd in the common view of this undesirable life form. You see, I chose math, science and computing as a career, and that seems to be enough to label me and many of my friends as nerds. We’re real-life Dilberts.

But what is a nerd? A dictionary definition is “a dull or ineffectual person; a person dedicated to nonsocial pursuit; a computer nerd.” What did I do to deserve this? I have a 32-year marriage; two grown, well-educated daughters; four college degrees; steady employment; a successful professional career; no arrests (except for one speeding ticket when I was 20) – even a 16 year-old cocker spaniel. Dull? Maybe, but certainly not ineffectual.

At one time, “nerd” was a somewhat jocular term, but the teasing has turned nasty. Now “nerd” normally is a term of derision. Nerds are a group of humans who can be attacked at will by those who either can’t or don’t understand modern technology, mathematics and science. Sometimes the intensity and harshness of these attacks remind me of the hatred directed at ethnic and religious groups by bigots.

That bigotry and bias has serious economic implications for the United States because of the inaccurate and negative stereotype associated with those who succeed in mathematics, science and engineering. High-technology job vacancies are legend, but United States teenagers and college-aged students view the field as one for nerds. In fact, a headline from the May 14, 1998, *Miami Herald* stated "United States workers shun 'nerdy' high-technology jobs." High-tech jobs pay 73 percent more than average private sector jobs. Demand for many technical specializations will climb over 100 percent in the next 10 years. Yet, the number of United States bachelor's degrees awarded in computer science and in several engineering fields shrank by over 40 percent between 1985 and 1995. In the mid- 1980s more than eight percent of the bachelor of science degrees awarded in the United States were in engineering; today, that figure has dropped to slightly more than five percent. During the past four years, the number of United States engineering jobs increased almost 20 percent to 2,051,000. The unemployment rate in engineering is 1.5 percent, less than a third of the overall work force unemployment rate; almost 200,000 United States jobs in computer and information technology are unfilled. Starting salaries for engineering baccalaureate graduates are approaching \$40,000, which is on a par with 1997 law school graduates, 40 percent higher than for business graduates, and 75 percent higher than for liberal arts graduates.¹

Instead of encouraging our students to pursue these lucrative positions, our media moguls paint high-tech professionals as laughable twits. Anyone who saw the movie "Independence Day" may recall the absurd portrayal of the scientist who headed a government laboratory charged with supervision of aliens from the alleged Roswell, New Mexico, incident. He was not just a nerd; he was a lunatic. I have worked at two United States national laboratories and I assure you the characterization was ridiculous. Scientific organizations are usually superbly managed by top-notch technical people. A September 7, 1998, Scripps Howard political cartoon showed an American couple sitting in their easy chairs while a smiling young alien with antennae, three eyes and huge ears walked by. The woman was saying, "I dunno. You think he was switched at birth?" The alien was carrying a book with the title *Advanced Trigonometry*.

A May 21, 1998, *Boca Raton News* headline read "Feds will learn: Bill Gates a nerd who likes to win." Is Bill Gates ineffectual? He is the richest self-made person in the world; his net worth is over \$50 billion and rapidly growing. The United States Department of Justice certainly doesn't view him as dull. The July 1998 issue of the magazine *Individual Investor* calls Gates the "world's ultimate geek." Webster's defines a geek as "a carnival performer who performs sensationally morbid acts, (such) as biting the head off a live

chicken." As far as I know, Gates is guilty only of biting the heads off some entrenched corporations and leading a high-tech revolution that is astounding in its impact. If Gates is a nerd and a geek, how about other superior entrepreneurs, inventors and scientists such as Henry Ford, the Wright brothers, Madam Currie, Thomas Edison and Alexander Graham Bell? All of these people enriched our lives through great discoveries and innovations. Future generations will view Bill Gates in that same category; yet, he's a nerd now.

But nerd bashing is getting worse. Now the media has discovered the year 2000 software problem (the infamous Y2K problem). This is a serious issue and it merits wide discussion about its causes and future prevention. But what are we often getting? Finger pointing and more name calling. In a recent column, Ellen Goodman of the *Boston Globe* blames the whole affair on "the very nerds in whom we trust our hard disks and our future." She rails about how stupid these nerds are for not recognizing the coming millennium. She blames it all on "a desire to save a couple of bytes." Hey, Ellen, when you last dated your signature did you use two digits instead of four digits? If so, imagine the confusion that may cause in the coming millennium. What Goodman didn't take the time to discover is that the root of the problem is economic. Cheap computer components are a relatively recent luxury. Earlier, computer memory was very expensive and its maximum use was economically essential. Saving two bytes made a real difference. Anyway, the decision to limit memory capacity due to cost was normally a management-imposed constraint that programmers had to accommodate. But to discover that fact might take a few minutes of time. Much easier to just bash the nerds. But we'll fix the problem for you anyway, Ellen; don't bother to thank us.

But Goodman goes further with her apparent bigotry. She writes, "In every family there is a computer whiz who can perform magical moves with his mouse, feats that stun his cyber-senile elder. That same whiz kid will then get up from the keyboard and go out to play in the snow without boots." Ms. Goodman, just because you can't program your VCR, you don't have to mock those who can. Regular people can and do understand science and technology.

Goodman also says these nerds "are assigned to be leaders in the 21st century." Well, nobody assigned me or elected me and my fellow nerds. Instead, we took challenging courses in middle school, in high school and in college. We volunteered and we succeeded. So now we're called names by people who act like bigots.

I wonder why Goodman doesn't spend some of her energy bashing her fellow star print, entertainment and broadcast media journalists, writers and editors who seem to

be incapable of forming a correct prepositional phrase or generally differentiating between subjective and objective cases. And I'm not even talking about sportscasting – where malformed prepositional phrases must be a job requirement. I read and hear phrases such as “between you and I” and “with she and I” so much now I'm beginning to wonder if I'm the one who has forgotten, or never learned, elementary school-level grammar. We should call these prepositionally challenged people *perds*. To date, I've never read or heard any popular or respected commentator even mention this issue. Maybe this is the Y2K problem of the literary and journalistic world; I'll bet the nerds solve their Y2K problem first.

But back to my main point. When I was an undergraduate in the 1960s, should I have avoided physics, mathematics, computer science and so forth and chosen a traditional liberal arts education? No, I wanted an education that included generous portions of an array of arts and sciences disciplines, including more than the – then required – basic science and mathematics courses. I advise today's college students to strongly consider the same path.

Why do I advise this? We often think of a liberal arts education as one that provides a fundamental knowledge of a variety of classical disciplines, sometimes defined as the arts, natural sciences, social sciences and humanities. Webster defines a liberal education as “one based primarily on the liberal arts and intended to provide maximum opportunities for self-expression or self-fulfillment.” But many of our liberal arts degree programs have abandoned all pretense of a truly liberal education because the level of science and mathematics education included there is too abysmal to allow sufficient individual growth and achievement in the 21st century. Meanwhile, specialized accreditation agencies and just plain common sense curricula design ensure liberal arts breadth and depth in science and engineering programs. It may shock you to know that most of today's Renaissance people are anything but liberal arts majors. Yet they're the nerds.

You think I'm wrong? About 10 years ago I read and outlined the descriptions of every undergraduate degree program in the FAU catalog. I was stunned. Easily the most restrictive and narrow FAU programs were in the College of Arts and Humanities and the College of Social Science. Some allowed *no* free electives. How can one find opportunities for “maximum self-fulfillment” with no freedom of choice? Few required any mathematics beyond the core curriculum requirement, which is high school or middle school material, at best. The College of Science allowed the greatest number of free electives. All colleges, including Business, Education and Engineering were more liberal in free electives than many liberal arts programs. I recently looked at FAU's 1998-1999 undergraduate catalog; little has changed.

Must we treat liberal arts majors as genetically inferior? Why does FAU offer two special math courses for liberal arts majors? Is it because the regular math courses are too easy? I don't think so. Is it because the regular courses are too applied? To the contrary, the liberal arts courses seem to be more applied than the regular math courses, which is a contradiction in the theory of liberal arts education. All FAU College of Business majors take a calculus course, so what's the big deal about expecting liberal arts majors to take unvarnished algebra and trigonometry classes? Amazingly, FAU liberal arts majors can graduate with no course in computing: a 1970s degree in the year 2000. FAU is similar to many other universities in this aspect.

So, you might say, are mathematics and that other weird stuff really important, anyway? In a March 1998 Scripps Howard News Service article, Robert S. Doran, who is chair of the Texas Christian University Mathematics Department, wrote, "Only in America do adults openly proclaim their ignorance of mathematics as if it were some sort of merit badge. Parents and students of other countries know that mathematics matters." He continues, "We live in a society that is literally saturated with math. Computers, electronics and gadgets of all kinds depend on it. Nearly every piece of factual information is put before us in mathematical form. Our height, weight, shoe size, the speed we drive – are all given in numbers. We talk of percentages, the cost of living index and the Dow Jones averages Ultimately, our nation's security depends on its mathematical ability because our nation's security depends on its mathematical capability Can attitudes concerning math in the United States be turned around? The answer depends largely on . . . whether we believe our children's futures are worth the price." Doran goes on to comment that "83 percent of all students who take algebra I and geometry go on to college; only 36 percent of those not taking algebra I and geometry go to college. Students headed for the work force with a solid high school math background earn, on average, 38 percent more than their peers without it. Yet, a 1996 report showed that only 25 percent of eighth-graders enrolled in algebra, thereby denying themselves access to higher-level high school courses. Many college-bound students stop taking math after the 10th or 11th grade using the justification they will never use any of this 'technical stuff.' If not, then why do the students who take more math earn more money?"

Doran states, "Mathematics is a profound and powerful part of human culture. Therefore, it is important to know something about it." Doran is right, of course. True Renaissance people cannot be ignorant of an entire field of study.

Let's take some practical and sometimes potentially life-saving applications of math and science. How many of us know what a logarithmic scale is? How many of us think it matters? Well, it will matter if you're in an earthquake that is a 7 instead of a 6 on the

Richter scale because the amplitude of the seismographs is 10 times as great and the energy released is 31 times as great, not 1/6 or 1/7 as great. How about the force of a 50 mph wind as compared to a 100 mph wind? "Twice as much?" you might say. Would you believe four times as much? This is one you should understand well if you live in South Florida. How many of us really know what "varies proportionally," "varies inversely," "varies exponentially" and "varies linearly" really mean? How about a correlation of +0.9, 0, or -0.9? Do you really understand the differences between probabilities and percentages or the differences between ordinal and interval scales? Do you know what a normal curve is? People who don't know what these mean should be treated as functionally illiterate and should not be entrusted with important matters of society in the 21st century.

Where is this all leading the United States? That's easy: the fittest survive, and the world has a lot of fit people. Over 40 percent of all students earning graduate degrees in engineering from United States universities are foreign-born; the figures for doctorates and postdoctoral positions are 50 percent and 60 percent, respectively. Forty percent of the doctoral engineers who reside in the United States are foreign-born, as are 30 percent of the engineering faculty at United States universities. In 1995, more than 65,000 engineers immigrated to the United States; that's as many engineers as this country produced in that year. Clearly, the United States must have the foreign-born scientists and engineers to compete; at the same time, we are increasingly dependent on foreign sources for critical human capital. State-of-the art R&D laboratories that rival the best United States laboratories are being constructed overseas, attracting graduates who, in the past, would have been inclined to stay in the United States after their education. Some foreign governments are offering financial incentives for top expatriate scientists to return to their homelands. While United States labor costs for scientists and engineers once were the highest in the world, we are now positioned very competitively – far below costs in Japan and Germany and only slightly above costs in Singapore and Taiwan. If we do not produce more scientists and engineers, soon United States companies will be compelled to export more R&D jobs and to pay higher labor costs for doing so. The United States is in a very risky position that has no economic imperative.² Ignoring our exposure is just plain foolish.

Is this disparity reflected locally? Absolutely. I taught computer science and computer engineering at FAU for many years. Increasingly, my graduate classes and thesis students often were composed of almost all foreign-born students. That is true of graduate science and engineering classes at FAU and almost all other research-oriented universities in the United States. In a large undergraduate class I taught this past

summer at FAU, almost 70 percent of the students were born outside the United States. Many of our faculty are from other countries, and that trend is accelerating.

Strangely, United States-born citizens sometimes seem offended by this influx of foreign talent. Well, I'm not. The foreign students are often superb; the foreign-born faculty are my colleagues and my friends, they bring fascinating cultural diversity to our campuses, and they are eminently qualified. Where would we be without them? If you do want to take a nationalistic view, then from the viewpoint of the United States economy and security, they are saving our hides; from the viewpoint of United States jobs, they are eating our lunch. The United States has always been a nation of immigrants; this is just the latest wave, but with a twist. Often, immigrants take the lowest-paying jobs and then work their way up; this wave has much better initial opportunities because of the rampant scientific illiteracy and avoidance within the United States.

We've developed a culture that not only overlooks ignorance, it sometimes even glamorizes ignorance. One can brag about being computer illiterate and not knowing the names Turing, Von Neumann, Hopper, Mandelbrot or Dijkstra. But admit you know those names but haven't read Shakespeare or Hemingway and you'll be branded a nerd. C.P. Snow claimed that a literary intellectual who could not briefly explain the Second Law of Thermodynamics was equivalent to a scientist who had not read a single work by Shakespeare. I'll bet today's United States scientists would win this one most of the time.

Are we making progress toward reversing this illiteracy? No. The results of the Third International Mathematics and Science Study were released in February 1998. The study included the developed European countries, the United States, Canada, Australia and New Zealand. Of the 21 participating countries, the United States 12th grade students were among the lowest-performing in both science and mathematics general knowledge; United States performance was below the international average in both math and science. This was true of our average and top students. Worse, the relative standings of United States students declines through the fourth, eighth and twelfth grades. United States student performance in the Advanced Mathematics and Physics exam was among the lowest of participating countries and was below the international average in both cases. The United States did not outperform any country in either case. This competition did not include developed Asian countries – so take the results as the best possible scenario.

Knowledge of elementary science among the older United States population reflects that of our students. In a recent poll conducted by the National Science Foundation, 53

percent of those asked did not know how long it takes the Earth to go around the sun, even though they were given the choices one day, one month and one year; one-quarter of Americans understand the nature of scientific inquiry enough to be able to make informed judgements about the scientific basis of results reported in the media; one in five Americans was able to provide a minimally acceptable definition of DNA; half the people believe earlier humans lived at the same time as the dinosaurs. Another poll showed that fully one-third of Americans seem to take witchcraft seriously, and more than one-half believe in some conspiracy theory complete with plots and cover-ups. I recall the terms “astrology” and “White House” often being used together a few years ago.

Who will lead us out of this mess? Few of our national political leaders have the knowledge to follow, much less lead, a revolution. One can be elected to the United States Congress without any evidence of achievement in or knowledge of technical matters. In fact, only a handful of United States Congress members claim past expertise in technical fields. A recent database search of the 100 Senate and 440 House members revealed that 51 senators list their previous occupations as attorney; none listed engineering. Maybe the closest is astronaut John Glenn. In the United States House, there are 160 attorneys, 60 business people, 18 professors, 12 real estate professionals, 3 journalists, 3 engineers and 1 scientist.

Does this under-representation of scientists and engineers in elective government positions affect the quality of our lives? In my opinion, absolutely. Look what our science-challenged federal government has brought us. Citizens cower in fear of convoluted, contradictory and inconsistent tax codes, afraid to do anything but pay taxes without any real understanding or ability to challenge the maze of special interest exemptions, adjustments and confusing calculations. Every “simplification” of the tax code just results in an economic boon for accountants and attorneys. One branch of government tells us not to use tobacco while another branch subsidizes tobacco farming while another branch taxes tobacco to pay the farming subsidies and the medical bills of the smokers. Balancing a budget is viewed as a challenge of infinite difficulty. Maybe this lack of scientific understanding explains a lot about the seemingly endless congressional malaise and why the members often debate the meaningless while ignoring substance. We wonder whether Republican-versus-Democrat and conservative-versus-liberal approaches to our national problems are best. We should enter science-versus-politics and knowledge-versus-ignorance into the mix.

Government's general ignorance of science manifests hostility, as well as ignorance. Recently Christina Hoff Summers, a Fellow at the American Enterprise Institute, wrote,³ "American pre-eminence in science and high technology is a major reason the 20th century will go down in history as the American Century. So it is astonishing, as well as dismaying, that some of our cultural custodians feel morally impelled to impugn American science in the public's eye and to minimize what American science and technology has done to improve our lives." Sommers reacted to a Smithsonian Institute exhibit titled "Science in American Life." She claims the exhibit mainly highlighted catastrophes, such as the explosion of the space shuttle Challenger. She concludes that government officials often display a hostility to scientific findings and even the scientific method, citing the National Institute of Health's support for alternative medicine, including the curative powers of the "Lakota medicine wheel." That animus shows up in financial support for anti-scientific educational projects such as *Women's Way of Knowing*, a book backed by the United States Department of Education that criticizes reliance on logic and data. Ms. Sommers concludes, "A scandalously inadequate system of science education and public disregard for clear thinking and objective truth are just the early casualties" of the government's anti-science practices. Ellen Goodman's tirade is a good example of this hostility. She never once commented on the tremendous advances attributable to computer technology; she was content to dwell on a flaw with no balancing analysis.

Look at the results of this bias and ignorance. Our judicial system sometimes feasts on the scientifically illiterate. High-profile criminal attorneys can convince a jury that virtually unimpeachable DNA evidence is less convincing than an elaborate, seemingly concocted and unsubstantiated conspiracy theory. Heads of major tobacco corporations swear under oath that they believe that tobacco use is not addictive or harmful to our health, even though decades of scientific study irrefutably show the opposite – evidence, they later admit, they knew about all the time but still felt could be hidden from a naive Congress and public. The United States public clamors for more about Monica and Bill while pretending they are offended by the scandal, but run away in droves if a serious discussion of global warming and its potential associated catastrophes is offered.

Sadly, some of our governments may actually depend on this prevalent illiteracy for economic survival. Increasingly, states and municipalities are allowing casino and other forms of gambling, in which the only sure long-term winners are the gambling houses and the governments' coffers. Instead of appealing to taxpayers fairly through

reasonable programs and taxation, governments seemingly prey on their addictions and illiteracy. This is a sorry situation and our political leaders should be ashamed of themselves. Could states really sell so many lottery tickets to a mathematically savvy public? Isn't it interesting that Florida citizens who would never vote for tax increases foolishly pour their essential dollars down the proverbial drain buying lottery tickets? I've heard a lottery defined as a tax on the mathematically challenged. Maybe Florida really can't afford an educated public.

So what is the solution? Why don't we simply do the obvious: encourage all United States students to achieve in mathematics and science. We could start by requiring calculus and calculus-based science courses of all of our college students, preferably before they are juniors. Giving college credit for high school mathematics arrests the intellectual advancement of the students; it is like teaching sentence construction twice, but never discussing paragraphs.

Impossible, you say. Of course not; millions of students, most foreign, learn calculus every year. Do we believe United States students really are genetically deficient? Challenge students and they will respond; society will be far improved for it. If universities require calculus, then the elementary, middle and high schools will adjust accordingly. We need to lead instead of pander to frailties and fears. But mathematics is not part of a traditional liberal arts education, you say. That is a cop-out. If the purpose of a liberal arts education is to expose students to the ideas of history's great thinkers, then how can we in good conscious exclude Newton, Leibnitz and the other great philosophers of mathematics and science? Surely they are as just as important as Keats and Shelly. As Fred Hoffman of FAU's Mathematics Department once stated to me, make calculus part of the humanities requirement. That idea is not as absurd as you might first think.

Calculus surely will open the way to better physics courses, better probability and statistics courses, better economics courses and a general awakening to science and mathematics for all students. I have no doubt it will also lead to better liberal arts courses because additional dimensions of understanding and discourse will be available. Moving forward in time, more citizens will be able to vote intelligently; maybe we'll even elect more scientists and engineers to public office. You see, the problem isn't that we have too many nerds; the problem is that we have too few nerds, and not enough nerds in high levels of government.

Calculus plus calculus-based science courses is my proposed solution, and I think it would work. Whatever the solutions, they need to be advanced soon by those who are most threatened. At risk here is not the survival of university mathematics and science

programs, but the survival of our liberal arts programs. The United States public will not indefinitely tolerate college degree programs that can produce functionally illiterate graduates. The signs of public distress are already everywhere. If the liberal arts faculty do not take the initiative here, it will be taken from them. All I am asking them to do is the same that science and engineering faculty already do: Recognize that a quality university education requires breadth and rejoin the broader university community.

We nerds are not the problem; we are the solution. So call me a nerd if that temporarily eases your insecurity. We owe no apologies for who and what we are. Knowledge always eventually wins over ignorance. Science and mathematics are intellectually challenging, the breakthroughs are often stunning, their underlying structures have great beauty and individuals who have chosen the fields are usually bright, well-adjusted, compassionate, and literate – just the opposite of the media’s preferred stereotype.

I invite all university students to join us; we’re having fun. And the pay is good, as I’ve mentioned before. So, you should become a nerd – if for no other reason than because, in the long run, surely the geeks will inherit the Earth.

¹ G. Campbell, Jr. Talent pool. *ASEE Prism*, October 1998, p. 52

² G. Campbell, Jr. Talent pool. *ASEE Prism*, October 1998, p. 52

³ C. H. Sommers. Fleecing Science and Reason, *The American Enterprise* 9, 5 (September/October 1998), 59-60.