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COMMITTEE ON EDUCATION AND THE WORKFORCE
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Thank you for the opportunity to submit this testimony.

I have been an Executive in Residence/Adjunct Professor with the Pratt School of Engineering at Duke University since September 2005. Before this I was a technology entrepreneur and co-founded two software companies.

At Duke University, I advise students on their career choices, lecture in classes, conduct research, and work with the faculty to better prepare our students for the real world. Based on my experiences as a technology CEO, there were two surprises in store for me in my discussions with students:

- The first was that some students were worried about having their jobs outsourced. They asked a question that I couldn't answer -- what courses would lead to the best job prospects and what jobs were "outsourcing proof"?

- The second was that 30-40% of Duke Masters of Engineering Management students were accepting jobs outside of the engineering profession. They chose to become investment bankers or management consultants rather than engineers.

This was a surprise as I had always believed that there was a shortage of engineers. I had expected that students from top engineering schools such as Duke's Pratt School of Engineering would take their pick of the best engineering jobs. After further discussions with students, I learned that some students saw more opportunity and expected better salaries in non-engineering fields. They were headed towards the greenest pastures.

With the assistance of Dr. Gary Gereffi, Professor, Duke University Department of Sociology, we initiated research into international engineering gradation rates and globalization trends in engineering jobs. We assembled a team of five students who worked for a semester to conduct the first stage of our research. Our goal was to understand the big picture and make recommendations on what fields of education would give our engineering students a competitive advantage.

Graduation Number comparisons of US-China-India

We started our study by analyzing the "facts". We wanted to establish a baseline for engineering graduation rates between the US, China and India. This would help us understand if there had been a trend over time for fewer graduates in US, more in India and China as more jobs are outsourced.

We published a report in December 2005, titled "Framing the Engineering Outsourcing Debate: Placing the U.S. on a Level Playing Field with China and India" (see attached). This shows that some of the most cited statistics on engineering graduates are inaccurate. Typical press articles have stated that in 2004 the United States graduated roughly 70,000 undergraduate engineers, while China graduated 600,000 and India 350,000. A press release by the National Academies in October 2005 announcing a report titled "Rising Above The Gathering Storm: Energizing and Employing America for a Brighter Economic Future" also cited these numbers.

Our study determined that the above comparison is incorrect. The commonly quoted numbers are based on reports issued by the Chinese Ministry of Education and outdated reports from the National Association of Software and Service Companies (NASSCOM) in India, who are generally considered to be the authorities on engineering graduation statistics within their respective countries. However, the statistics released by these organizations have included not only four-year degrees, but also sub-baccalaureate degrees and certificate/diploma holders. These numbers have been compared against the annual production of accredited four-year engineering degrees in the United States. Additionally, these numbers include not only engineers in traditional engineering disciplines such as mechanical, electrical, and aeronautical, but information technology specialists and technicians.

To produce an accurate comparison, we totaled the bachelors (four-year) and subbaccalaureate (three years or less) degrees awarded in engineering, computer science and information technology in the United States, China and India. We reported that in 2004 China awarded 644,106 of the aforementioned degrees, India awarded 215,000 and the United States awarded 225,925.

Looking strictly at four-year degrees and without considering accreditation or quality, in 2004 the U.S. graduated 137,437 engineers, vs. 112,000 from India. China reported 351,537 under a broader category. All of these numbers include information technology and related majors.

We were able to reach a level of comfort in comparing the US and India numbers, but noted that the Chinese numbers were suspect. We had to rely on information provided by the Chinese Ministry of Education and could not gain comfort with their method of collecting information or the rigor in validating data. The Ministry of Education told us that their aggregate numbers were obtained by adding the numbers of "engineering" graduates as reported by different provinces. These provinces were not required to report on degree by major and that there was no standard definition of engineering between the provinces.

There were also questions about what qualifies as an engineering program in China. It appeared that any bachelor's or short-cycle degree with "engineering" in its title was included in their numbers regardless of the degree's field or the academic rigor associated with it. This means that the reported number of engineers produced may very well include the equivalent of motor mechanics and industrial technicians.

After the report was published, we were told by a visiting Chinese scholar that the numbers supplied to us by the Ministry of Education for 2004 were actually 2003 numbers. The newly released "2005 Chinese Statistical Yearbook" states the combined number of 2004 bachelors and subbaccalaureate graduates was 812,148. There was no indication what degrees or fields of education were included in these numbers, however.

We subsequently obtained a document written in Chinese from the website of the China Education & Science Research Network which contained a breakdown of degrees for 2004. When we added the engineering majors comparable to those the US and India, the total for four year bachelors came to 349,000.

Last semester we researched the Chinese numbers further. A new team of students contacted 200 of the 400 Chinese universities that graduate engineers. We were able to gather 2004 graduation data from 30 of the larger schools. We were told that these universities together graduated 29,205 in fields which they classified as engineering. Most universities could not give us detailed or usable data. We were able to get 2005 graduation data from 77 universities. The main conclusion we could draw from these data was that universities were reporting significant increases in graduation rates for engineers in 2005 over 2004.

Why are these numbers relevant?

We hear repeatedly that because India and China are graduating twelve times the number of engineers as the U.S., we are at risk of losing our competitive edge. We hear demands that the US double the number of engineers it graduates to keep pace with India and China.

I believe that the US does need to significantly increase its investment in education; this is one of the most valuable investments we can make. We need to improve our math and science curriculum and find ways to get our engineering graduates to stay within the engineering profession.

I also believe that we need to be more effective in commercializing our university research and to find ways to have America corporations keep their research in the U.S. My belief is that there are many problems which need to be fixed and that some of these don't require massive investments.

By focusing just on the graduation numbers, I fear that we are coming to the wrong conclusions. All it took was a team of five students working for one semester to prove that the basic premise of a key argument was incorrect; India and China simply don't graduate twelve times the numbers of engineers that we do. If you compare engineering graduation rates to population, it is clear that the US is far ahead and will be for a few more years; and this assumes that an average American engineering graduate is equal to an average Indian or Chinese graduate.

Are we really comparing Apples to Apples?

There is a major difference in quality of education between the US, India and China. Our study did not analyze this, but all available data indicates that the vast majority of Indian and Chinese graduates are not close to the standards of US graduates. As India and China increase their graduation rates, it appears that educational quality may actually be decreasing. The Chinese graduation numbers seem particularly suspect as it appears that their educational focus is quantity vs. quality.

While it is clear that China is significantly increasing the number of engineers and technology specialists it graduates, the data indicates that there is a factory like approach to turning out graduates. Duke researcher, Ben Rissing notes that degree quality can't be maintained unless academic staff and facilities grow with student populations. Rissing cites China's technical school system, which is used to educate a portion of China's highly skilled technician population. Despite a 100% increase in technical school enrollment over the past five years (over one million students enrolled in 2004), China has been decreasing its total number of technical schools and their associated teachers and staff according to the Chinese Ministry of Education (MoE). From 1999 – 2004 the number of technical schools in China fell from 4098 to 2884, during that same period the number of teachers and staff at these institutions fell 24% (National Bureau of Statistics of China, 2005 China Statistical Yearbook. Table 21-22).

While technical schools are designed to provide students with industry specific skill sets, institutions of higher education educate students in a variety of disciplines, including three- and four-year engineering offerings. The MoE claims that despite the last five years of significant increases in student populations, China's institutions of higher education enjoy a student to teacher ratio of just over 16:1. However, under closer inspection, the MoE acknowledges that full-time teacher numbers include teachers from "other schools" (National Bureau of Statistics of China, 2005 China Statistical Yearbook. Table 21-32). These statistics raise serious questions about the quality of upcoming Chinese engineering and technicians' degrees.

India's most respected educational institution is the Indian Institute of Technology (IIT). Over the years, it has graduated many successful entrepreneurs and leaders. Anecdotal evidence indicates that IIT graduates are exceptional, but so are the graduates of top U.S. schools. Biomedical Engineering Professor Barry Myers says that he has always been impressed with IIT graduates to come to study in the U.S. But these students are only as good as the average American students that he teaches at Duke. The IIT's are challenged by comparatively weaker infrastructure and have been impacted by the private sector recruiting their faculty into new research institutes. Professor Myers says that IIT Deans have visited Duke to recruit recent graduates from his program to teach at their schools.

Do we need more engineers?

Salary data for US engineering jobs and anecdotal evidence does not indicate any shortage of US engineers. Simply doubling the graduation rates of engineers without first understanding what types of engineers are needed to maintain our competitive edge may lead to unemployment and a reduction in salaries. This will have the effect of deterring future generations of Americans from studying engineering.

As India and China develop their infrastructure, they will need more engineers. They need more civil engineers, electrical engineers, and mechanical engineers, for example. The U.S has already developed its infrastructure and does not need to simply match the growth rates of engineers in India and China to remain competitive. There is likely to be a high demand in certain engineering professions in the US, but there does not appear to be sufficient research into what these areas are.

Engineers develop renewable energy sources, advancements in technology, solutions for sustaining the environment and improving healthcare. They also manage projects and lead innovation. There is little doubt that we need more of the right types of engineers. The question is what do we need more of? If we do graduate more engineers, how do we motivate these graduates to stay in engineering?

What should we do?

Education and Research

First, we should look critically at the overall education system and continually improve quality. The best way for the nation to stay competitive is to have the most educated and motivated workforce. It is clear that there are issues in K-12 education and American children don't study enough math and science.

Effective investment in research provides competitive advantage. We certainly need to invest more in research; but we also need to look at how we can gain more from our existing investments.

As an ex-technology executive in academia, I have observed a chasm between the business world and academia. The priorities are different and so are the objectives. I would not do anything to change the way research is done or to lose the freedom that our universities enjoy. I would however look into ways to bring industry and academia together and to create effective partnerships for research commercialization.

Better industry-university alliances will also provide incentives for corporations to keep their research in the U.S. Universities have a wealth of untapped talent that can make America more competitive. Focused investments can strengthen the research abilities of our universities. These are advantages that countries like China and India simply don't have – their struggle is to graduate enough engineers to keep pace with their growth.

Understand what gives us a long term competitive advantage

Second, we should determine exactly what engineering skills will give us a long term advantage and focus on producing more of those.

In our study, we tried to differentiate between the skill and education level of engineers and concluded that those with higher-quality education would always stay in demand. We differentiated between "dynamic engineers" and "transactional engineers". Dynamic engineers are individuals capable of abstract thinking and high-level problem-solving. These engineers thrive in teams, work well across international borders, have strong interpersonal skills, and lead innovation. Transactional engineers may possess engineering fundamentals, but not the experience or expertise to apply this knowledge to larger problems. These individuals are typically responsible for rote and repetitive tasks in the workforce.

One of the key differentiators of the two types of engineers is their education. The capstone design course that some U.S. engineering students study in their senior year enables them to integrate knowledge gained from fundamental coursework in the applied sciences and engineering. Programs like Duke's Masters of Engineering Management take this a step further and provide engineers with the skills needed to become "business-savvy" engineers who are better able to address the complex technical and business issues associated with technology innovation.

Contrary to the popular view that India and China have an abundance of engineers, recent studies show that both countries may actually face severe shortages of dynamic engineers. The vast majority of graduates from these counties have the qualities of transactional engineers.

Differentiating between dynamic and transactional engineers is a start, but we also need to look at specific fields of engineering where the U.S can maintain a distinct advantage. Professor Myers lists specializations such as systems biology and personalized medicine, genomics, proteomics, metabolomics that he believes will give the U.S a long term advantage.

Our education system gives our students broad exposure to many different fields of study. Our engineers learn biology and art, they gain significant practical experience and learn to innovate and become entrepreneurs. Few Indian and Chinese universities provide such advantages to their students.

Understand corporate America needs

The fact is that some jobs will be outsourced. We need to determine what types of jobs will not be outsourced and understand the long term needs of corporate America. If a certain type of engineering job can be done more cost effectively in India or China, why should we invest in graduating more of those types of engineers?

Extensive research is needed and surprisingly little information is available on what types of engineering graduates corporate America will need in the future. My team at Duke is presently conducting such research. This will be little more than a drop in the bucket, but we need to gather all the information we can.

Conclusion

The numbers that are at the center of the debate on US engineering competitiveness are not accurate. The US may need to graduate more of certain types of engineers, but we have not determined what we need. By simply reacting to the numbers, we may actually reduce our competitiveness. Let's better understand the problem before we debate the remedy.