MEGATRENDS IN ENGINEERING EDUCATION

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Abstract

In 1982 John Naisbitt introduced a new technique of gleaning trends in our society in his best-selling book *Megatrends* – content analysis. He based his futurist predictions on a detailed analysis of what the news media were reporting, by taking time to connect individual events to begin to understand larger patterns. His premise was that the most reliable way to anticipate the future is by understanding the present.

This paper looks at recent and current events in engineering education at the international scale, as reported over the past three years in the *International Engineering Education Digest,* and attempts to connect them in ways that reveal megatrends in engineering education. From the rush of universities to get into for-profit distance education ventures, to the worldwide drive toward harmonization of degrees and their quality assurance mechanisms, to downturns in engineering enrollments due to student disenchantment with the profession, the topics repeated in the monthly issues of the *Digest* provide a pattern that helps to illuminate current megatrends, and to project them into likely future directions.

Introduction

Was spring 2000 one last season of irrational optimism in the United States? On January 14 of that year the Dow Jones Industrials hit a high of 11,722.98. It wouldn't be until June 1 that manufacturing data and a monthly unemployment report showed the first concrete signs that the US economy was cooling. Do you remember when the Fed actually raised interest rates? They did on May 16, 2000, when they bumped it up by .5 to 6.5%. Back then, 911 was still a US phone number, the Euro had yet to be born, and on March 22, Pope John-Paul II, on a visit to Israel, pleads yet again for a homeland for Palestinian refuges.

On May 1, 2000, the *International Engineering Education Digest* (the Digest) was born. In the three years since then, the global economy has tanked, political tensions have risen

to a cracking point in about 25% of the nations of the world, terrorism has become a common reality for everyone, and it has never been more important for us all around the world to step back and take a global assessment of where we are.

If you need a reminder of how quickly the US scene has changed, read the following from the first Digest: "An article in the 18 April 2000 *Wall Street Journal* indicates that US defense companies are having difficulty attracting young engineers. Staff reporter Anne Marie Squeo writes that cutbacks in government funds to aerospace and defense firm make jobs in those industries less secure, so younger engineers are shying away from them. Young engineers are instead being attracted by the Internet economy, and its computer and software firms" (Digest 1 May 2000).

Using three years of the *International Engineering Education Digest* as a data source, and with the luxury of hindsight, four major themes emerge from the world of engineering education:

- Changes forced by the fragile world economy;
- Student and professional mobility;
- The use of communications and instructional technology;
- The increasingly loud voice of the social imperative.

These individual themes are complex enough, but when taken together they are intertwined, interactive, synergistic, and strike to the core of not only engineering education around the world, but also of higher education in the new millennium.

<u>The economy</u>

"An investment bank has made a deal . . . that will have it pay for one-third of the cost of a new chemistry building in return for a share of the profits from any spin-off companies in the next 15 years. … The bank . . . is confident that it is getting a good deal, on the basis of its own expertise and experience in advising high technology and biotechnology companies" (Digest 18 December 2000).

Presumably, the university's confidence was equal to that of the bank.

This Digest article captures the changing scene of higher education, where, in the face of decreased funding, universities are making more aggressive and complex business deals in hopes of shoring up resources. The famous university in question, Oxford in the UK, has been strapped for funds as are sister institutions in the US, Ghana, Vietnam, Venezuela and Australia.

Since 2000 money has been exceptionally tight for higher education around the world. As the world economy has faltered, colleges and universities have been forced to adopt strategies for increasing revenues and decreasing costs. Among those strategies are instituting or raising tuition, changing research funding, finding efficiencies in traditional operations, and developing new, for-profit business ventures. The current environment has also been hospitable to the growth and expansion of new educational organizations

around the world, both for-profit and not-for-profit.

From a US perspective, where both public and private institutions have long flourished side by side, the notion of paying for higher education is not new. Even public universities have raised what were originally modest rates of tuition and fees long decades ago to a point where the difference between the cost of attending a public and a private institution may today be minimal. In the US discussions about college costs have been dominated by arguments over how much to raise tuition in the face of budget shortfalls, and the relative balance between loans and grants for students attending college. Missing are broad-based debates on whether higher education is at all the responsibility of the state.

But elsewhere in the world, expectations, history and culture are different. Students have traditionally attended universities for free, or have paid only symbolic costs, or even have been paid for attending a university. That is fast changing, as the Digest has reported. In 2002 Canadian students protested increased tuition which raised the average student debt load to about 15,600 US$ (Digest 18 February 2002). The Association of African Universities endorsed the imposition of tuition in its 170 member institutions spread through 43 countries, places where higher education has traditionally been free. The implications for the poorest of the poor are clear, but the trade offs are painful, especially in view of the crises in health care, starvation, and employment, all of which present competing priorities. A later report, picked up in the Digest (5 August 2002), predicts increased chaos in already unstable African universities in light of these new changes. An interesting side note is a recent entry (Digest 6 May 2002) that reports the decision of the government of Slovakia to make fees for distance education illegal. In addition to their regular curriculum, which is free of charge, many Slovakian universities have been offering such distance education courses, citing great need and popularity. The universities claim that without charging for them, they will be forced to close them down. The government says that all education should be free. Stay tuned.

Under conditions of budget constraint, research funding is undergoing major changes around the world. Long-standing assumptions are being rejected, and the national infrastructures which have controlled the distribution of research funds have been remade. Japan, for example, created a new super ministry for funding research, presumably based on the need to better coordinate projects and assess progress and success (Digest 26 January 2001). Other countries, long dedicated to virtual lifetime funding support for researchers, have begun to impose productivity measures on their researchers and to withdraw funding for those whose output is not judged sufficient in quality or quantity. The Chinese Academy of Science has been moving in this direction across its 123 research institutes (Digest 10 March 2001). Northwestern University in the US vowed to do the same (Digest 10 March 2001). The European Commission, acknowledging the fragmentation in its programs of scientific research, has set in place a four year, 16.2 billion US$ program (Framework 6) to promote pan-European projects and trans-European mobility for researchers. Targeted support is to include: information technology, genomics and biotechnology, sustainable development and global change, nanotechnologies, aeronautics and space, and food safety (Digest 10 March 2001). The

French government has attempted to boost research spending, but most of it has been defense related, and civilian R & D funding was scheduled to only barely beat inflation rates (Digest 12 October 2001). Argentina has been especially hard hit, closing labs, reducing researchers' salaries, and facing radically devalued funds (Digest 8 April 2002).

A significant crisis in scientific publishing is driven largely, but not exclusively, by economics. Universities are seeking to maintain their traditional ways of acquiring and making available research findings, but at reduced costs. As an economic problem faced by all colleges and universities, the problem to many seems amenable to solution by the Internet. Just put journals on line immediately: low cost, instant access to ideas, free scholarly inquiry, etc. Not so fast, say publisher representatives (Digest 12 October 2001). Quality costs money. So the question and the solutions linger. Although not seen as central to the interests of many engineering educators, in the light of current world events the related problem of book publishing of works in Arabic takes on an added interest. With 275 million speakers of Arabic throughout 22 countries, a run of 5000 copies of a book by Middle Eastern publishers is considered large (Digest 24 August 2001). Something to think about.

This grim global scene of the funding available for all of higher education is lightened somewhat when we look at the creative ventures of some institutions attempting to balance their meager budgets. In the UK, for example, eighteen universities banded together to offer advertisers an opportunity to promote their products or services on the university screen savers (Digest 12 October 2001). (Holy pop-ups!) The British government also offered a onetime bonus to educational institutions that decided to go private and forego public support (Digest 15 February 2001).

More serious financial maneuvers have included efforts by Temple University of Philadelphia to start a for-profit online school, which was closed down when a new president took over (Digest 3 August 2001). California had to rethink its interruptible service contracts with energy providers after considering what cuts offs would mean to medical facilities, laboratories and such (Digest 15 February 2001).

While the impact of communication and instructional technology in engineering education over the past three years will be discussed in the next section of this paper, we need to spend some time here considering how technology has offered entrepreneurially minded university administrators some dazzling opportunities for making money. The Digest is full of articles about how this university or that around the globe has plunged into production of on-line courses or modules in hopes of making money, only to be disappointed. It didn't take the dot.com collapse for universities to learn that the investment needed to create quality online programs was heavy and the profits did not quickly roll in to help balance the university budget. There have been some creative efforts to use the new ventures to compensate individuals, a welcome innovation in view of generally stagnating salaries in higher education. University College Cork staff, for example, working at the national Microelectronics Research Center, were in line to profit from commercial spin-offs. The center decided to distribute half of the equity gained to its

staff members (Digest 18 December 2000). More than one university has seen the advantages of encouraging faculty to be creative online and to reap profits, to blunt the effect of minimal raises.

There are limits, however, to efficiency measures and creative entrepreneurship when it comes to managing the financial existence of a college or university. The strong growth of private and for-profit institutions of higher learning around the world has attracted a great deal of attention. In country after country, the tradition of a single, publicly funded system of higher education has given way in the face of increasing demand for access which outstrip national resources. Governments have admitted candidly that they cannot provide places for all the qualified students in their countries who want to attend college, and thus have created legislation and policies which invite, encourage, and support the entrance of private money into their countries for building new universities.

In the US, educators have become familiar with such entities as corporate universities (Digest 6 May 2002, also 15 February 2001), and private for-profit programs (Sylvan Learning Systems, the University of Phoenix, etc.). Along with their growth has come a tension, articulated by some as the conflict between the need to retain quality in education vs. the perceived monopoly that traditional institutions have on the delivery of higher learning in the US. This tension arises whenever another country contemplates expansion of educational opportunities offered by anyone other than traditional institutions. Since resolution of this issue requires some complex evolution of social expectations placed on national governments, should developing countries defer decisions on creating increased educational opportunities for their young by rejecting what may prove to be some questionable initiatives from abroad? Is there a need for new academic credentials to aid in this challenge? Can we grasp the urgency of the problem just by looking at China, where only about 11% of its young attend college?

The overarching concerns that these budget squeezes create, exacerbated by the creative solutions proposed in desperation, are ethical ones. Who benefits from higher education, the individual or the society? If the emphasis is on individual benefits, should universities try to turn that around? What is the pay back expected of a university graduate to the society which funded his or her education? Who should fund research? Are public-private partnerships inevitably tainted? Should private donations, complete with limitations and conditions, increase or decrease? Engineering educators are centrally involved in these deliberations, on both a local and a global scale. Their contributions to the dialogue would be valuable.

In the end, it is difficult to attribute lessening support for higher education solely to the current state of the world economy: that is today's explanation/defense. Tomorrow will likely be the same, with a different excuse. The case for education, as the solution for society rather than one of its many problems, has not yet been made.

Technology

The complexity and interconnectedness of the challenges facing engineering education are nowhere better seen than by looking at instructional and communications technologies. Certainly technology has been viewed, as outlined above, as an opportunity for earning money for institutions and individuals, thus relieving some budget problems. Technology also offers cost-cutting solutions by creating operational efficiencies. Communications and instructional technologies are a means of increasing access to higher education, and thus are related to the social imperatives facing higher education. It is a way of increasing student and professional mobility, through virtual visits, courses, recruiting and communication. Technology has been offered as a means of increasing the effectiveness of both teaching and learning. In fact, technology has been such a driving issue in engineering education that it has merited its own category in the Digest.

In reviewing the past three years of the Digest we can see evidence of a substantial amount of rash behavior related to technology, with decisions being made quickly, only to be retracted in the light of the inexorable forces of reality, profitability, feasibility, readiness and politics. While we learned long ago that technology hardware was not cheap, it has taken a bit longer to accept that integration of technology into teaching, learning, research and life is neither cheap nor easy.

Technology's potential for increasing access to higher education was immediately evident and is now visible throughout the world. An African Virtual University is up and running (Digest 6 May 2002). Japan, Thailand and Vietnam are among the countries considering establishing an "international cyber-university" (Digest 6 May 2002). China is working with US and Australian universities to offer more distance education programs taught in English (Digest 6 May 2002). The Indira Ghandi National Open University is using FM radio and TV satellite downlinks for its programs, the largest in India, serving 750,000 students (Digest 18 March 2002). An on-line Islamic university now functions in the US (Digest 5 August 2002).

Huge investments have been made in instructional technologies in the US. When the bubble burst, with dot.coms and the economy going belly up, some say that engineering was buffered because it had used technology wisely (Digest 26 November 2001).

While admiring the ability of various technologies to increase access to higher learning and their suitability to engineering education, we cannot escape the problem that much of distance learning has yet to be assessed in terms of learning outcomes. We have probably come too far to have the entire enterprise collapse, and the alternative -- persistent ignorance around the globe -- is too dangerous to consider. But we need to attend to assessment, to have a better grasp on what really works when we use the tools of technology in the instructional process. If more students do not learn more, more effectively, more efficiently, with better retention and ability to use what they have learned, why use technology?

Communication and information technology (CIT) has been a great boon to international contacts among engineering and science researchers. There is no need to provide examples

to prove this point. And for engineering students who can communicate with their peers around the world, there are great advantages. However, this great potential has yet to be systematically exploited to offer students international exposure through technology and to expand the reach of international engineering meetings and conferences to engineers in the developing parts of the world. In fact, the digital divide appears to be increasing, as forward motion in developing countries is slow, while advances in technology, software, hardware and individual competencies accelerate in other parts of the world (Digest 18 March 2002).

The variety of technology-related projects, programs and activities in engineering education has produced important results, including some which were unintentional. For example, it has become apparent to anyone who has engaged in distance education that modern teaching includes several discrete functions which must be decoupled in order to achieve the desired learning results. Instructional designers and technology experts are now active members of the teaching team which traditionally included only a professor plus graduate assistants (Digest 22 September 2001). This can lead to a feeling of loss of control on the part of faculty, but probably also a welcome sense of humility and appreciation for collaboration. A developing history of the use of instructional technology has even allowed the definition of new problems and the vocabulary with which to discuss them. Take, for example, the notion of "linkage rot," the tendency of links to become outmoded over time, as sites disappear or are renamed or relocated (Digest 6 May 2002). "Linkage rot" is real evidence of the half-life of most technical knowledge, and how fungible knowledge and evidence are, both valuable pieces of understanding.

The pervasiveness of English as the dominant language of higher education and research has been emphasized and intensified by technology. King Faisal University (Digest 8 April 2002), a private institution in Saudi Arabia, has recently opened, using English as its sole language of instruction. South Korea expanded its courses taught in English to attract more international students. (Digest 3 August 2001). While having a dominant language of communication across higher education has some great advantages, it also can create a false confidence in steadfastly monolingual American engineering students that English is the only language they need, and that concurrent with the growth of English has been the disappearance of cultural differences. It is for engineering educators to emphasize that this is not true, and to create learning experiences which prove this to their students. False expectations about the very real cultural and linguistic differences which cover the globe can limit engineers' effectiveness in the exercise of their profession in the global marketplace.

Student and professional mobility

"Student mobility" and the Bologna Declaration have become more familiar subjects since the European Union began to focus attention on the need for its students to be able to navigate more smoothly the European "space of higher education" without regard to borders (Digest 12 April 2001). For engineering educators, it is particularly important to consider also professional mobility, as professional engineers and educators have

increasingly higher expectations of being able to navigate the labyrinth of licensure and practice requirements around the globe.

In the US since September 11, 2001, the media have given intense coverage to immigration, immigrants, and the governmentally sanctioned policies and practices for controlling access by outsiders to the United States. H-1B visas now are being discussed by people who didn't know they existed when the millennium arrived. When the Digest began in May 2000, it was still plausible to consider expanding the quota of specialists granted entrée into the US for specialized needs, in particular in science, technology and computer science (Digest 1 May 2000). The scene quickly changed, however, with the downturn of the economy and the upturn in terrorism: requests for H-1B visas dropped, and professional groups began to view those who advocated for higher quotas as the modern day equivalents of scabs, attempting to flood the market with lower-paid engineers and computer scientists from overseas to the detriment of native-born professionals seeking work in a difficult economy. For those with eyes to see, the immigration issue in the US was only part of a similar dynamic being felt around the globe (Digest 8 April 2002). "Australia has slammed its door to the 'less civilized,' the U.S. border with Mexico has been strengthened, Britain plans to increase requirements for immigration, and Germany is grappling with integration of immigrants. Some of the increased barriers to immigration are the result of 9/11 concerns, while others are economically motivated" (Digest 8 April 2002).

We should note that mobility to some is brain drain to others. Students and engineering faculty have proven to be particularly adept at following the best the world has to offer, regardless of national borders. US engineering educators have been provided with large quantities of statistics describing fluctuations in the national origins of their students (Digest 22 October 2002). Figures usually demonstrate that the number of US students ready, willing and able to engage in higher education in engineering are in decline (Digest 26 November 2001), while large numbers of international students wait eagerly in line to take their places in US universities at both the graduate and undergraduate levels. Once a comfort level had been achieved with the strong presence of overseas students in science and technology programs in the US, questions began to be raised about where these overseas students would go once having earned a degree (Digest 22 October 2002, and 2 December 2002). Then related questions were posed: about student mobility across the states of the US; about the quality of US primary and secondary schools as related to student interest in and readiness for advanced studies in engineering and technology; and about the nature of and need for a diverse student body, what it takes to achieve it, and at what cost. Engineering faculty face the issue every time they enter a classroom or laboratory; it is worth the effort to step back and consider the large issue of why we are where we are.

With demographics demonstrating what is already being felt in countries such as Germany and Spain – the dearth of college aged populations – mobility, even in the name of economic integration across Europe, can sometimes be threatening. Spain is already experiencing a decline in the college age cohort, with universities under the gun to attempt

to back-fill with expanded programs, and Germany is rapidly growing gray, with dire predictions of accelerated decline in technical prowess. Being suddenly thrust into competition with excellent universities in nearby countries, competition for both students and faculty can be perceived as another impediment to economic stability.

Brain drain is on everyone's mind. Despite economic downturns, the US remains a prime destination for engineers and engineering educators from overseas who want to benefit from dynamic ideas and a comparatively wealthy economy. The Digest has reported on numerous initiatives taken by governments around the world to retain their best scientists, researchers, and educators, in face of the lure of the US (Digest 12 October 2001). The Canadian government, for example, recently set out tax incentives for keeping Canadian-born scientists at home (Digest 1 January 2001). But while some countries seem still not to get it, and persist in making marginal and defensive moves to prevent mobility, Tanzania's leaders have demonstrated that they get it: they have instructed their universities to educate the young to be "job creators," not "job seekers," thus virtually mandating the inclusion of entrepreneurship in the education of future engineers (Digest 12 April 2001). To the young and ambitious, the lure of being able to prosper at home by using their engineering education in start-up enterprises is often enough to prevent plans for migration abroad.

Professional mobility for engineers has everything to do with accreditation and licensure issues around the world, and the Digest has recorded this issue in some detail. Efforts continue to create some consistent standards, enabling engineers to practice outside of their home countries (Digest 26 November 2001). Of course, licensure issues immediately raise quality control issues, along with accreditation issues, resulting frequently in a hot mix of idealism seasoned with turf protection and national defensiveness (Digest 18 March 2002). But the search for common global grounds for quality standards, fair employment practices, and useful application of human resources goes on. That this section of the paper is not longer is less a reflection on the importance of this theme than it is of the lack of real progress that has been made over the past three years.

The social imperative

While students from around the world strive to acquire the strongest possible technical education in engineering, some older hands persist in proclaiming that the ill-named "soft skills" are the ones which will ultimately be key to the successful practice of engineering by up-and-coming engineers. But the list of "soft skills" too often is limited to things such as public speaking techniques, management skills and the ability to work well in teams. What is missing is an understanding of how the growing social consciousness around the world is making it imperative that engineering students understand the implications of their work. Technical skills applied without regard for the ultimate result of the work can lead to the creation of world societies characterized by the worst dreamed evils. Technique without conscience, we know, is a danger.

The Digest has placed an emphasis on diversity from the very beginning, and recognized

that diversity means different things in different societies. Stagnation or weakness in the pool of students eager for engineering education has finally reached a point where even some of the most conventional thinkers agree that the student body must be diversified to more accurately reflect national and regional populations. This means, in different countries, different mixes. In countries such as Iran and Afghanistan this means that particular attention must be paid to disengaging young women from the religious strictures which limit their attendance at school and their pursuit of education outside of national frontiers (Digest 4 January 2002). The US continues to wrestle with the value and legality of affirmative action in higher education (Digest 22 September 2001). In a country such as India, the challenge is to enroll more of the outcasts of the caste system (Digest 27 March 2001). Of course, this sort of expansion of the pools results predictably in calls for more quality control, as new sorts of students challenge the norms established by . . . the establishment.

How to integrate ethical issues into the engineering curriculum remains a work in progress, along with how to prepare students to work and live well with people whose culture, language, skin, religion are different. The Digest has not recorded very many efforts in these directions, but the overwhelming coverage of the destructive results of discrimination makes the issue self-evident. Ethical issues covered in the Digest, and which should be a part of engineering education include:

- what responsibility the young have to giving back to the world for their education;
- consideration of the extent to which research should be driven by the needs of society rather than the curiosity of the researcher;
- intellectual property issues, especially in light of the wide-spread perception that western aid is too often a guise for western theft of ideas from developing countries;
- how to combat the technological divide;
- how to promote and educate for entrepreneurism;
- how to assure the quality of engineering practice;
- assessment of what engineering societies are doing around the world to solve the social issues, not to exacerbate them;
- sustainable development, and international aid programs;
- how to keep borders open for those involved with teaching, learning and creation, without imperiling national security in face of very real threats;
- how to instill in students a sense of ethics in their university studies which will carry over into their professional conduct;
- the extent to which engineering schools should invest public and private funds into regional international development;
- whether technology can bring about more social equity.

The social imperative inherent in the practice of engineering presents a huge potential agenda, one which individuals, universities and professional organizations around the world must attend to. Most recently a UNESCO/OECD study called "Financing Education – Investments and Returns," (Digest 3 March 2003) demonstrates a positive correlation between secondary and post-secondary education and economic recovery. It validates the view of those who have been urging engineering educators to recognize their

key roles in forming young people who will apply engineering skills to solving global problems.

Our research technique

The *International Engineering Education Digest* is published electronically every three to four weeks by Dr. Russel C. Jones, a longtime engineering educator, on the basis of the many papers, conference proceedings, magazines and journals that he reads regularly. The *Digest* is copyrighted by World Expertise LLC, with all rights reserved. While Jones as editor uses personal judgment in selecting items that he feels are of appropriate interest to engineering educators, the Digest entries are straightforward summaries of the items. For the current paper, all the items in Digest editions since May 2000 have been reviewed by Dr. Bethany S. Oberst, James Madison Distinguished Professor and international administrator who has a background in both the humanities and technology. In the preceding pages Oberst, who recently began collaborating with Jones on the Digest, has identified megatrends in engineering education, and higher education more broadly. In the conclusion which follows Oberst and Jones make some observations about likely trends in the future, based on the backsight provided by the Digest items of the past three years.

Concluding observations

- Although the economists of the World Bank and the International Monetary Fund have failed in improving the status of people in poor countries through attempts at stimulating economic growth with foreign aid, we must find effective ways of 'teaching people how to fish' instead of sending them fish. Engineering education and technology development can provide the base for capacity building which leads to economic benefits from engagement in the global economy, as well as to the effective local utilization of foreign aid resources guided by indigenous engineers.
- Take care for China! Its sheer size makes it important: the welfare of many millions of people depends on the quality of decisions being made every day in China and elsewhere. The fate of the Chinese people is inextricably linked to the fate of their education systems.
- Engineering students increasingly need to be educated for international practice. Programs of study should include education in languages, cultures, and mores of foreign countries. International experience through study abroad and internships are a must. Faculty need to show the way, with their own international activities.
- More engineers must act as public intellectuals, drawing upon broad-based skills and experiences to provide articulate leadership in the modern world.
- While graduate education in engineering in the US still is the best in the world measured by its attractiveness to students and faculty, it falls short from a US perspective in two respects. We Americans want and need more applicability and social progress. Our popularity abroad should not blind us to the shortcomings we, as insiders, can discern (Digest 26 January 2001).
- Effective quality assurance systems are needed for all engineering education programs around the world. Mutual recognition agreements to move toward acceptance of

educational equivalency are a must to allow appropriate mobility for practicing engineers.

NOTE: All back issues of the *International Engineering Education Digest* are posted on the web at http://www.worldexpertise.com

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