A NEW VISION OF ENGINEERING EDUCATION AND LICENSING

Stephen Armstrong, P.Eng., CEO of AMGI Management Solutions, international trustee of IMechE in London, and a speaker at PEO's Future of Engineering Education and Licensure Conference in June 2007, is an internationally trained engineer who took an unusual path to the profession. He offers a unique perspective on engineering education and licensing in this country.

JENNIFER COOMBES: Having grown up in Northern Ireland, you achieved your P.Eng. via quite a different route than most Canadian or internationally trained engineers have. Could you describe a bit of your background, and what you're doing now?

STEPHEN ARMSTRONG: In the high school system in Northern Ireland, after you study for General Certificate of Secondary Education O levels, you can continue for A levels and then university. My choice, at age 16, was to leave high school to serve a five-year aeronautical engineering apprenticeship with Short Brothers and Harland in Belfast, the oldest aviation company in the world.

My teacher at that time told my friend I was making a big mistake leaving school instead of staying on for A levels. But the school teachers knew nothing about careers in industry, and engineering was perceived to be an inferior choice.

Every year there was a structure to the apprenticeship. The first year was in the training school learning milling, machining, electrical, sheet metal, etc. After the first year, we specialized. You'd spend six months in the factory itself. I happened to go into the jig and tool department where they build the aircraft. We also attended the local technical college one day and two evenings a week studying for academic engineering qualifications.

After two and a half years, you could apply to get off the shop floor and into the technical office. I got into the manufacturing engineering department and specialized in the development of tools and manufacturing

processes. So, after the five years I was already highly skilled at design, drafting, tool design and manufacturing process development.

The City & Guilds full technological certificate in production engineering was awarded after five years. So, in broad academic terms, it would be equivalent to a three-year Canadian or American engineering technologist diploma but, quite frankly, it was far superior because you also had five years of structured competency-based apprenticeship.

At that point, I didn't want to stay in Northern Ireland with the civil unrest. I was ambitious and my dream was to continue my education. So, I applied for a degree course at London Polytechnic, now the University of Westminster. In 1980, I graduated with a BSc honours in mechanical engineering.

One of the things about degrees in the UK is that they're tightly connected with the professional engineering institutions. The idea is that you're not a fully qualified engineer until you achieve the chartered engineer qualification. Usually, you achieve that after four to six further years beyond your bachelor's degree, mastering specific competencies in industry and being monitored by the institution.

For my post-grad training, I specialized in developing advanced composite materials for aircraft structures, as a contract engineer. I went back to Belfast for six months and worked for Lear Fan Aircraft, a company that was building the first-ever, six-seater composite aircraft.

In 1981, I immigrated to Canada and worked for de Havilland, designing the leading-edge tooling for the Dash 8. Then, it was on to Hughes Helicopters in Los Angeles for a year to design the tooling to make the Apache helicopter composite rotor blades. This was followed by two more design contracts in Toronto at IBM and Pratt & Whitney.

One of the requirements to be a chartered engineer is to supervise people and take charge of a project. After my work in the aerospace industry, I joined a power equipment company called Brown Boveri as an industrial engineer implementing the Honeywell manufacturing management software and became manager of manufacturing engineering. I was 27. Because I had that supervisory experience, I got my chartered engineer (they usually like to see a minimum age of 30).

The funny thing is I got my P.Eng. before my chartered engineer. PEO focused narrowly on academic requirements–it was like the apprenticeship didn't matter. I found the UK CEng more rigorous. It's 20 years later and PEO is just getting around to adopting a postgraduate structured approach to internships to achieve the P.Eng., whereas the UK has had that in place for a long time.

After obtaining the CEng/P.Eng., all I did was work from then on. It's only in recent years that I've started to want more academic development in a different field.

While working as a manager, I got interested in implementing advanced manufacturing systems with a special focus on the human side of change. I was always more interested in the psychology of people in the workplace than I was in the development of artifacts. Developing aircraft, cars, ships, planes, is boring for me. It's the people and the project execution that turn me on.

After working in marketing at Honeywell, I joined Stevenson Kellogg Ernst & Whinney, which is now known as KPMG, starting as a senior management consultant. Eventually, I became a principal in charge of the manufacturing systems group. Through this, I learned management consulting, and especially how to transform companies, and gained the skills for managing cultural change. That's when I really took off. My first major assignment was with Ernst & Whinney, USA in St. Louis at McDonnell Douglas (manufacturers of the F-18 and F-15). I worked on a team to develop a future state vision of the company to the year 2015 and, really, it changed my whole life because, first of all, I realized I was working at the highest level I could and I fit in like a glove at the strategic management level. I realized that that was my true calling and I never wanted to go back to technical design work again. Helping others innovate became my primary focus.

But my ambition was always to run my own ship. In 1993, I set up AMGI Management Solutions and signed a contract at de Havilland Aircraft, where eventually I invented and developed Bombardier's engineering management system (which started off at de Havilland) and published a book, *Engineering and Product Development Management*, for Cambridge University. This system is still used to develop Bombardier's new aircraft. I continued to conduct business transformation work in various sectors, including aerospace, media, food, pharmaceutical, machine tool, electronics and a large number of SMEs [small and medium enterprises] and family-owned businesses.

JC: What are some of the lessons Canadians can learn from the British educational system?

SA: I think industry, and even the professional institutions, should combine with universities to create maybe a six- to eight-year degree course.

One of the big problems in the Canadian system is the total focus on the academic and not enough on practical experience during the degree. Quite honestly, these one-year co-op degrees are a joke compared to a UK apprenticeship.

But I want you to know that the UK didn't encourage their graduates to do an apprenticeship before entering an engineering degree course. I just happened to do that and they would do well to adapt something like that here. It creates more rounded people.

The other thing about the British system–the way I used it anyway–was that if you happened to fail something you could at least fall back on what you had achieved. If you couldn't hack it in the technical office, you could go back to the shop floor. And if you couldn't hack it at the academic level at university, you still had your technical qualifications from college to fall back on. There were ladders and bridges.

This system evolved because of the traditions dating back to the medieval apprenticeship approach. It's not like somebody in the UK did a grand design.

I remember the P.Eng. being a degree plus two years of experience. I found the experience requirements weak. I was always interested in liberal arts. I thought that was the purpose of an MBA, until I observed that MBA courses focus mainly on finance and marketing. There was a total absence of leadership, psychology, history or any of the liberal arts.

In the old UK apprenticeship system, you're exposed to these issues on the shop floor and technical offices. Even in technical colleges, we had liberal arts within our City & Guilds or HNC [Higher National Certificate] courses. We had debating societies.

Plus, in a structured apprenticeship, it wasn't just showing up for work. In the training school there are all kinds of classes–how machines work, how fluids work, how cutting tools work, supervision skills–as well as the hands-on stuff.

The apprenticeship was about the greatest thing I ever did and the foundation of my future success. Thank God I didn't listen to the high school teachers. It allowed me to have marketable skills that I could sell to industry as I developed my career.

JC: Engineers have titles in the UK, but engineering is not a licensed profession. What is it like to be an engineer in the UK, and what is the public's perception of the profession?

SA: Let me make it clear that in the general UK society, the word "engineer" is totally misunderstood. The current situation is very confusing. IMechE [Institution of Mechanical Engineers] has been around since 1847, the civils since 1810. These institutions, as learned societies, have great historical value and credibility. But engineering in the UK is not considered to be a profession like it is in Canada. It has a serious image problem. And there's no law backing up engineering practice. Every Tom, Dick and Harry calls himself an engineer in the UK. If you watch *Coronation Street* the mechanic is referred to as an engineer. British Gas claims to have 180,000 engineers, but they're really plumbers.

If my mother said to someone, Stephen is an engineer, they'd look at her strangely because they would think I'm a car mechanic. They'd be confused that I have a degree. And so she just tells them that I'm a consultant, because doctors are called consultants so it sounds better.

The UK's title, chartered engineer, is administered through the Engineering Council UK and is protected in law, and incorporated engineer [technologist] and engineering technician are also protected. But they're only titles with no meaning when it comes to protecting the public.

I've been appointed a trustee of IMechE and am on a licensing investigation committee. What I've learned through exposure to this committee is that the Canadian model is one of the best in the world because it backs up the terms engineer and engineering practice by law.

By contrast, what I've found is the Canadian learned society is very weak. The Canadian Society for Mechanical Engineering, for example, has nowhere near the credibility of IMechE. When you walk into the buildings of the UK institutions, you're connecting with some of the greatest people on the planet who have gone before.

What PEO has done with licensing has advanced the role of engineering in society. It has weaknesses, but it is a good foundation. And I think one of the greatest creative things that Canadians did was the branding of graduate engineers with the iron ring.

JC: Can anything be done to change this perception in the UK?

SA: In Canada, the licensing system has some traction. Nobody in industry here would question what an engineer is. The UK public thinks of an engineer as a maintenance or "fix-it" person–it's an image issue, not reality. And yet the chartered engineer training and status among themselves is incredible.

The mechanical and civil engineering institutions all realize they have to become more outward facing because their profession is in serious decline. Young British students are not entering engineering. School teachers are not learning chemistry, physics and mathematics. Everybody's going into media studies and soft degrees. So, UK engineering needs to be rebranded.

My goal is to design a new governance model for professional engineering across the Anglo-Saxon countries to define clear boundaries between licensing and registration bodies, learned societies, advocacy and academe. They all have very different roles.

I do think PEO itself really has to rethink its convoluted role...it's primarily licensing and protecting the public, not advocacy or learned society. PEO is a true licensing body, but they dabble in learned society activities and promoting engineering when they really shouldn't be doing that. They should be focused entirely on licensing, and if they're going to promote engineering they should do that as a separate organization.

When the PEO president meets the IMechE president, it's like apples and oranges. Yes, the IMechE accredits degrees, as does PEO, but it doesn't license. When Walter Bilanski [PhD, P.Eng., PEO's past president] talks to the IMechE, he doesn't realize how they think. And the IMechE people don't know what licensing truly means.

I remember facilitating a meeting between PEO and IMechE and each had different frames of reference that created confusion.

Kim Allen [P.Eng., PEO's CEO/registrar] and I have talked about this and we think engineering needs more clear demarcation between the objectives of the different elements of the profession. So, my ambition is to take the best of the Canadian system and American system, which is much more visionary than in Canada or the UK, and integrate them.

JC: You're a strong proponent of postgraduate education as a minimum for licensure, and you believe in the value of engineers gaining a well-rounded education–in history, philosophy, literature, and so on. What do you see as the perfect educational mix that would produce engineers capable of handling 21st-century challenges?

SA: Well, I think the total time to create a professional engineer is 12 years with, as I said before, an eight-year degree. I'm not saying that they should be paying university fees for six, seven, eight years. I'm saying that the four-year academic model is fine, but it should be an eight-year process–a combination of vocational competencies plus academic where the university is tightly connected to the local industry.

The master of arts in the history and philosophy of science and technology that I'm doing part-time at the University of Toronto is very demanding. It's not an add-on for engineers. Its purpose is to create professional historians and philosophers.

I'm not saying that engineers should undertake this kind of rigour, but they need some kind of serious graduate courses in philosophy, history, business psychology, and maybe leadership. And if they get it through an

MBA, okay, fair enough. But I don't like the way MBAs are taught. They have become money-making channels.

JC: If you could make one immediate change to the current educational or overall licensing system for engineering, what would it be?

SA: Actually, there are several. I think engineers should start to go more into private practice and move away from the employee model. They should sell themselves as professionals to industry because, once you're an employee, you lose true objectivity and creativity may be dampened.

Many employees are afraid to take the risk and go out and make change happen. I've spent 15 years running my own show. It's tough but rewarding and I think that's the model that future professional engineers should aspire to. If engineers are to become true, independent professionals, they need a more rigorous program during their formative years.

Society will need more high-end engineers in the future to run the massive technological systems for environmental sustainability, etc. The engineers in leadership roles should be so specialized, so capable, that they should be able to go into the free market and sell their unique services. That's a true professional, not being an employee, hiding behind corporate security, and basically working in technician roles. Working in private practice will create the kind of super-engineer that Walter [Bilanski] talks about.

I think also that if you want to make the P.Eng. relevant, embed it as part of the degree. But that would require the universities to envision an entirely new role for the engineers of the future, not just train them for a job.

The university should take an integrated approach with the professional licensing bodies as well as industry to produce super-engineers who will manage our technological world. This will give engineers a far higher profile in society, will raise the brand, and will provide people who understand science, technology, management processes and, most importantly, social-cultural change.

I also think PEO should start to have specialist designations similar to medicine. They have them but they're not robust enough, just loose names for mechanical, industrial, etc. I'm a member of the Institute of Certified Management Consultants, but a P.Eng. with a CMC qualification has competencies far beyond a regular management consultant who's just an MBA. I'd like to see management engineer become a designated specialist, where you understand how to manage large-scale technological change.

A lot of management consultants who are selling their services don't have the hands-on professional engineering background to help companies manage technological change. They have the business and soft skills, but unless they're engineer-MBAs they don't have the foundation skills.

As I mentioned, I would get the university engineering professors to sit down with industry and hash out an eight- to 12-year formal program to produce super-engineers. I would say you could probably have three levels of engineer. You could have a doctorate engineer after the 12 years and it's not a doctorate based on research, it's a doctorate based on a combination of academic and vocational competencies. Engineers can find their own path, whether research, management, or large-scale change management, as independent practitioners. They also can become regular technical engineers. So, I see a structured approach to this where each person can continue to grow and even change paths.

At U of T, I have been exposed to career history and philosophy academics and I admire them. But there is an ivory tower feel to many engineering professors who fall short on managing the integration of human social-culture, technology systems and money. Their ownership and emphasis on engineering academics creates gaps in forming an engineer. Academics are only one dimension of creating a total engineer.

They might say they cover the humanities dimension but it is dabbling. If we want engineers to go into politics, we're going to have to create a broader person when they are young and it is impossible to develop this at university. It doesn't require just add-on liberal courses, it requires character formation on the job. That's why I say eight to 12 years of an integrated path: academics, vocational competencies and cultural change management.

A team at the University of Michigan has come up with a very interesting future state vision. They're talking about engineers the way I am, where they're looking to see engineers become independent and they're looking for an eight- to 12-year formation. While they're doing their internship, they're paid by industry, but industry is getting a lot from them, too. It's back to the old UK apprenticeship model. It really is the best method to form a holistic mind at a young age. Σ