

Kennedy-Wunsch Lecture 2020

Fifty years a chemical engineer

Jenny Culliford, 19 November 2020

I am honoured to be invited to present this year's Kennedy-Wunsch lecture. Professor Kennedy was Head of Department when I studied at the University of Canterbury and supervised my final year research project *Kinetics of a weak acid ion exchange resin*. This was in 1969. I still have a bound copy of the report.

When thinking about this presentation, I thought the title *Fifty years a chemical engineer* was appropriate as our class graduated fifty years ago in May 1970.

As the title suggests, I will outline my career and some of the more interesting projects and activities I have been involved with. I sense there is interest in what it has been like being a woman in engineering, particularly in the early years. I also thought it might be interesting to mention some of the notable changes in practice since 1970, particularly computing and safety.

College education

I must start by talking about my college education. I was a most unlikely candidate to become an engineer. There were no engineers in my family. My secondary school, Sacred Heart College in Lower Hutt, did not teach physics – we all did the nutrition option in general science in the 5th form. This was a time when the school leaving age was 15 and the percentage of students, especially girls, doing four or five years secondary education was rather lower than now.

There were six of us in my final year, presenting a challenge to the school in arranging classes for us. I was the only one studying maths and after being turned down by the two closest colleges, Sr Mary Bernard, our principal, was able to arrange for me to take maths classes at Hutt Valley Memorial Technical College in Petone where I was made very welcome. They set their timetables for scholarship maths and additional maths so that I needed to go there just once a day. Most days I cycled the three kilometres, occasionally I had our family car and sometimes the nuns lent me their car. My other subjects that year were chemistry, Latin and French – not a conventional preparation for engineering.

Why chemical engineering?

When considering what to courses to take at university I was attracted to chemical engineering. The idea of studying towards a profession appealed and maths and chemistry seemed to be a good foundation. Careers advice I received in my last year of school was of little help. After filling out a questionnaire, I was told off by the adviser for not taking it seriously enough and wasting her time. Whatever I did, I should not study medicine and the best thing to do would be take a course in geography. Very baffling!

University years

My engineering intermediate year was at Victoria University in Wellington. At that time, it was expected that you would do the intermediate year at the university closest to home. Government-funded boarding allowances were not available for courses that could be undertaken at your home university.

There was very good support for engineering intermediate students in Wellington. We could complete our 80 hours of workshop practice at a local technical college and there was encouragement to complete the first of the three required practical work attachments.

The intermediate year comprised four subjects: pure and applied maths, chemistry and physics. This was a challenging workload, particularly if your only physics knowledge was some mechanics taught as part of maths. However, I passed the intermediate and turned up in 1967 to start the First Professional course at Canterbury.

There were around 35 of us that year and three of us were women – Vicky Brown, Margaret Clarke and me. The arrival of three women was a new experience for the Department. Thongtip Hongladarom from Thailand had just finished her degree and Jenny Seagar (Boshier) was in the year ahead of us. Professor Kennedy arranged for Mary Earle to come down from Massey to talk with us. Mary still comments on receiving a call requesting she meet with this unexpectedly large intake of female students. None of the other engineering departments had women students at that time so we were very conspicuous at shared lectures such as engineering maths attended by the whole first professional year cohort.

The Canterbury degree required the completion of three periods of practical work each of 60 days (480 hours) – two were to be mechanical workshop and one professional practice. Generally, working some overtime was needed to meet the time requirements and have some time left for a holiday.

My first period of practical work was in the toolroom at General Motors home appliance factory, followed a year later by work in the maintenance team at Unilever and for professional practice, filtration studies at the Department of Scientific and Industrial Research (DSIR) in Lower Hutt. Interestingly, I did not have much difficulty finding the vacation work although when at Unilever, I did have to agree to having my photo with spanner in hand for the local paper leading to much teasing on my return to Canterbury. The practical work was quite well paid as far as vacation work went. My friends who had holiday jobs in shops and offices were somewhat envious of the pay but not of the work.

First employment

My first two and a half years were spent in research, first with the Wool Research Organisation of New Zealand in Lincoln and later with the DSIR in Lower Hutt. In retrospect, the Wool Research position did not provide me with the ideal first job. They employed two of us from our class, but they had not previously employed any professional engineers and so had no experience in how to use young graduates. I felt the lack of a mentor during this period.

However, I was involved in some interesting work including techniques for deposition of polymers into wool fibres to make them coarser and then dyeing the treated wool. The treatment had been developed for wools to be used for carpets.

There was interest from a Christchurch woman prominent in the fashion industry who wanted to make wigs from wool. I spent some time working on dye formulations to dye the treated wool in a range of hair colours using wool dyes rather than hair dyes. We then had a batch of treated wool dyed and the first wool wigs were manufactured and marketed. Occasionally I could be seen sporting a short, curly wool wig leading to the embarrassment of acquaintances who did not recognise me.

I transferred to the DSIR working in the Chemical Engineering Section where my main project was a study on the extraction of wax from Chatham Islands peat at both laboratory and pilot-scale. We looked at peat from different sources on the Islands, how best to prepare it and tried a variety of solvents. My lasting memory is of stacks of laboratory glassware encrusted with wax and resins which were exceedingly difficult to clean.

It was towards the end of this period that I encountered my first experience of overt discrimination in my career on account of my being a woman. The DSIR had a history of supporting its young engineers to study for a PhD at an overseas institution. I duly applied to study at Cambridge and was accepted by the university but turned down by the DSIR on the grounds that it was too much to ask a young woman to make a commitment for six years – three years study followed by three years bonded employment. I was a bit put out at the time. However, I now consider that this rejection turned out, in fact, to be an opportunity to spread my wings.

This decision reflected the attitudes of the time. There was not an expectation that women would combine a career with marriage and family. A few years earlier when applying for a bank loan to buy a car, the bank manager told me that they did not normally lend money to young women on their prospects.

The time came to move abroad for a mix of travel in Europe and work in England.

Great Britain

We arrived in London on a bleak November evening in 1972, never imagining that this was the start of a 12-year OE.

During this period, I worked for a traditional-style British consultancy, LH Manderstam and Partners. Major Len Manderstam was born in Riga in Tsarist Russia and had an interesting military history prior to starting up his consultancy practice. His memoir is entitled *From the Red Army to the SOE*. He was recruited to the SOE in 1939 and was later appointed head of SOE's Russian section. At the end of World War 2 he led protests against the forcible repatriation of millions of Soviet prisoners but to no avail.

The Major would lunch every day in a small hotel opposite the office in Grosvenor Gardens. He would invite a member of staff from time with all new recruits receiving an invitation. I had the pleasure of dining with him and his son or a client on a few occasions.

Manderstam and Partners were involved in projects ranging from cotton ginning in Egypt, to oil refining in Ethiopia, to a steel mill in Indonesia. It was here that I had my introduction to environmental work which did not have the high profile that it does today. We carried out an environmental impact study commissioned by the Secretary of State for Scotland on the proposal to build concrete oil platforms on the west coast of Scotland. I was given responsibilities in both technical and social aspects of the study and spent an interesting time gathering data and interviewing in the area.

In January 1974, the British Government brought in the Three-Day Week restrictions to conserve electricity, the generation of which was severely restricted due to the effects of the 1973–74 oil crisis, and later compounded by the coal miners' strikes. Commercial users of electricity were limited to three specified consecutive days' consumption each week. We, however, continued to work a full week in our offices in the house in Grosvenor Gardens, using gas lamps and heaters.

Iran

An opportunity arose to work in Iran and in January 1975 I moved to Ahwaz in the south of Iran with my husband. We had been interviewed in London for these jobs by one of the principals of the Dutch consultancy, Mecon, who was surprised when we turned up for the interview. He was expecting brothers. However, he employed us both.

Mecon operated only in Iran with its head office in Tehran and a second office in Ahwaz in the operations centre of the oilfields. I was the sole process engineer in the Ahwaz office until the company expanded considerably two years later. The arrangements were unusual in that our company had only one client, The Oil Services Company of Iran (OSCO), and competed with other consultancies for work. The distribution of work was overseen by the powerful and well-named Dr Family. My job with Mecon gave the opportunity to work with a diverse range of people as the company employed Dutch, Iranian, British, Indian and two New Zealand engineers, Iranian and British draughting staff and Iranian tracers. Our counterparts, the project engineers from OSCO, were a mix of Iranian, American, British and Dutch. Most of the client's foreign staff were seconded from their parent oil companies, the "Seven Sisters", many of them staying several years.

It was during this period that I made real progress in my professional development. The work in Ahwaz mainly involved the expansion of oil production facilities and the provision of utilities. We worked in all the southern oilfields and on Kharg Island. Our involvement in a project was usually from the preparation of the initial engineering report and costing for approval by OSCO's management through site and/or pipeline route selection and detailed design including production of construction drawings, preparation of specifications and purchasing schedules and tender analyses where required.

One of our more unusual projects was the provision of buffer storage for NGL – the Mile 40 finger storage as it was known. It comprised eighteen 300m long 'fingers' constructed of 42-inch pipe. The NGL was diverted from, and pumped back into, the main pipeline feeding the NGL refinery at Bandar Mahshah on the south coast. This did not prove to be a lasting

monument to our engineering efforts – a few years later we were watching a news report about the Iran-Iraq war and saw the installation being levelled by Iraqi jets.

I did not encounter difficulties being a woman working in Iran at that time. There were no restrictions on travel, in fact I still have my Iranian driving licence. Frequently site visits were made alone except for the company driver. It was advisable to dress reasonably modestly, to avoid inviting undue attention. During Shah's reign young women were encouraged into tertiary education and those with good English language skills were in high demand for well-paid jobs in companies servicing the oil industry.

The revolution saw the end of our time in Iran which had lasted four years.

Great Britain – the return

On our return to Great Britain at the beginning of 1979, I found a position in the London office of an American oil- and gas-field equipment supplier, C-E Natco, where I worked until our return to New Zealand early in 1985. It was particularly good experience working for a supply company where the emphasis in all projects was profitability. It was the first time that I had worked in such a commercial environment.

My first work with Natco was as a project engineer working on the design and supply of a large crude oil desalting plant for Das Island near Bahrain. The bulk of the design was carried out in our Tulsa, Oklahoma office with client liaison, purchasing and equipment fabrication coordinated by the team in London.

Later, as a senior project engineer, I took sole responsibility for several projects. For a period our office was structured such that engineers could be required to take responsibility for a project from the initial quote and price negotiation with the client through to final shipment. This was excellent experience and very good for the character. There was only ever one person to blame if things went wrong or if, in the final analysis, the bottom line did not show the level of profit required.

One of my more interesting projects was a turnkey gas choke and dehydration plant for British Gas at Hornsea in the north-east of England. The gas we were treating had been stored under high pressure in underground salt cavities during periods of low demand. Our plant comprised indirect heating, filter separators, pressure reduction an absorption column and glycol regeneration skid.

During my time at Natco, I was responsible for the supply of a wide range of equipment including gas dehydration plants, gas/oil separators, glycol regeneration units and indirect gas heaters to many countries including Iraq, Iran, Egypt, Angola and Great Britain and the North Sea.

It was not unusual to be mistaken for a secretary or assistant. Occasionally when I attended a meeting with a junior male colleague, people would address matters to him rather than me, assuming he was the senior person. This sort of thing also happened with people telephoning and asking to speak with the engineer or the boss when I answered. This did not bother me. I had a job to do. It was their problem not mine.

Return to NZ

On our return to New Zealand I took two years out to spend with my young children and then at the end of 1986 I joined Morrison Cooper in Wellington. They were ahead of their time in that they agreed to my working part time, the only constraint being that I worked five days a week. I started off working around 22 hours a week and gradually increased this to full time over a few years. For my part, I agreed to make site visits or attend out-of-town meetings provided I had adequate notice to arrange childcare. The arrangement worked very well.

As happens with consultancies, Morrison Cooper went through a few mergers and name changes to Kingston Morrison, Sinclair Knight Merz and, most recently, Jacobs. I retired from Jacobs in 2014 after 37 years with the company and its forerunners in New Zealand. Over that time in addition to various project roles, I held several management positions as mergers and restructures unfolded and I was invited to become a shareholder of Kingston Morrison.

Morrison Cooper was a leader in the design of freezing works and cool stores and also undertook significant projects in food, including dairy, and the timber industries and were involved in World Bank and Asian Development Bank projects.

In the early 1990s, we were engaged by Pitman Moore who were developing an animal vaccine plant on the site of Tasman Vaccine Laboratories (later Coopers Animal Health) in Upper Hutt. The first vaccines had been manufactured there in 1951. The new global vaccine plant was commissioned in 1993 and continues to operate and export globally, now under the ownership of MSD.

This was a new experience for Morrison Cooper. We were used to food industry hygiene standards and now needed to understand global regulatory requirements for sterile vaccine manufacture. The plant was validated successfully without delays or dramas. This project led to an interest and further work in the pharmaceutical/biopharmaceutical area with other New Zealand and international companies operating at various levels of sterile production and bio-containment requirements.

The merger with KRTA brought the opportunity to work on geothermal projects. As the late Tim Dobbie described in his Kennedy-Wunsch lecture two years ago, KRTA had an impressive history in the development of geothermal resources in New Zealand and overseas, particularly in the Philippines, Indonesia and Kenya. Geothermal steamfield development shares similarities with oilfield development, so my experiences in Iran were valuable. It was soon after the merger that I was given my first geothermal project to manage and made my first of several visits to the Philippines.

Kingston Morrison continued to undertake work in the food industry, primarily dairy, and other industries. In 1999, the company joined Sinclair Knight Merz (SKM) and our New Zealand team took on the design of a major dairy plant upgrade in Queensland. It took us a while to become accustomed to different operational requirements from those we were

used to in New Zealand and also to the manner of working of our Australian colleagues who were responsible for the building and civil works.

Over time, there was more focus on geothermal projects than on industrial by SKM's Power and Industrial group in New Zealand. My roles were more often as a project director or technical reviewer. Also, I was Practice Leader for food engineering where I could contribute globally to food industry projects.

For me, working in a New Zealand consultancy required versatility and flexibility to work in various industries and with a range of clients and to adapt to the changes in emphasis of my employer through the years.

Professional activities

I have been involved in a diverse range of professional activities. The highest profile of these would be my membership of the Engineers Registration Board (ERB) and involvement with the introduction of the Chartered Professional Engineers of New Zealand Act.

I was first appointed to the ERB in 1994 and after three years was selected to be the Chair, a position I held for six years. The Engineers Registration Act dated back to 1924 and was out of step with other occupational regulation in New Zealand and similar legislation in other countries. Once registered, engineers were required to do no more than pay an annual registration fee.

In 1998, the case for a new act was presented to the Minister of Commerce after consultation with various stakeholders. Issues to be addressed included ongoing competence, adherence to a code of ethics and accountability. New legislation was to set a quality mark for professional engineers. The Engineers Registration Board made a significant contribution to the development of the new act which came into force in 2002 with IPENZ as the Registration Authority. The Engineers Registration Board served as the Chartered Professional Engineers Council during the transitional period, pending the appointment of new members to the Council. This process took over a year. Consequently, we undertook many of the establishment activities.

I have been a member of several university engineering course accreditation teams representing IChemE and/or IPENZ. This has mostly been in New Zealand although I have also been involved in accreditations in Malaysia and Singapore.

Currently, I am on the Board of IChemE in New Zealand and from time to time interview candidates for chartered membership.

Another role I currently hold, and have held for some time, is Disciplinary Committee chair hearing complaints against chartered professional engineers and members of Engineering New Zealand. This involves two or three cases annually. The disciplinary process is important in upholding standards and the reputation of the profession. When hearing cases I am always conscious of the potential effect of any decision on a person's career.

I served as a director of Agri Quality, a state-owned enterprise for three years until it merged with Asure to form a new entity under the direction of a new board.

Computing

An area that is very different from when I started out is computing. At university we used slide rules and log tables. We had a brief introduction to Fortran programming. Calculators were coming in but were bulky, slow, and limited in their applications. Computer bureaus started to appear.

In Iran we had access to the client's computing facilities. I recall needing to do some two-phase fluid-flow calculations for a pre-engineering study on a gas pipeline. This required submitting programming for the client's punch card operators – always remembering to tick the box for printing the information on the top of the card – essential should you have the misfortune to have the bundle dropped. After checking, the programme would be run overnight with the output available the next morning. Then it would be back to the office to check it all, identify any errors or additional cases to be run and then through the process again, although if you were dealing with just a few changes you could punch the cards yourself. Each interaction involved a 7km drive each way from the office to the computer facility.

When I joined Morrison Cooper, we had a small number of shared computers for which you could book a time slot. Competition for a slot could be fierce. Computers represented a significant investment for consultants, and it was common to charge a small hourly fee for computer use. Gradually personal desktop computers appeared and, rather later, laptops. Looking back from today's powerful computers, it is hard to remember how we managed with the limited computing power and resources at our disposal. The days of manual drawings are far behind.

Safety

Over the course of my career, health and safety practices in employment, design, operations and construction have changed hugely. I look back at some of the practices that were accepted in my early career and cringe, and wonder that there were not more accidents. Now we have robust legislation and regulation with accountabilities in place, there are specialist process safety engineers, training courses are available covering all aspects of health and safety, and IChemE with the Safety Centre is a leader in this field.

Over the years I have had several roles with safety responsibilities both project and operations related. I have facilitated numerous HAZOPs and HSE risk workshops both for SKM projects and for external clients. For four years I was Regional HSEC Manager, a role that covered all operations in New Zealand.

For two years I was Governance Practices Manager in the global HSEC team. This was a new role, brought about by the accountabilities new legislation, particularly in Australia, was placing on company officers. I monitored that projects identified as having high HSEC risks were taking adequate steps to manage their risks. We also provided support to, and regularly audited, global business unit leaders to ensure they were adequately informed about their unit's operations and the level of compliance with the company's systems and local legislation.

Reflections

I have mentioned some of my experiences directly related to being a woman working in engineering. Clearly when I started out there were not many of us in New Zealand. Numbers in the chemical and process engineering classes at Canterbury have increased. This year there are 66 undergraduates and 16 post-graduate students - just under 40%. There are women across all the disciplines, although chemical still has the highest numbers among the classic courses. As the numbers have grown, it is likely that today's women students feel less pressure to succeed. I hope so.

Being one of a minority group leads to being asked to participate in activities to promote the group. I was a member of IPENZ's schools liaison committee, appeared in brochures promoting engineering to girls, judged various competitions, spoke at careers evenings and so on. Such exposure leads to further recognition and invitations to contribute to more professional activities and also creates other opportunities.

I appreciate the support I have received from my family who accommodated my absences on work trips and often long hours of work, and the support of my colleagues over the years.

So that is a brief summary of my fifty years as a chemical engineer, from my perspective an interesting career, a time during which I have seen massive changes in engineering practice and the tools available, a career where I think being a woman provided more opportunity than discrimination. The hot topics have changed as society's pressures have changed – environmental and sustainability issues have been with us for some time, and now climate change is the big number to be tackled.

I wonder what today's graduates will be most concerned with 50 years from now.