Pioneers of Science Education #13

David J. Waddington (1932-): Context-based science education – the Salters' approach

Figure 1: Professor David J. Waddington (Photo: Department of Chemistry, University of York)

Introduction

I have known David Waddington since the early 70s and have been in touch with him, on and off, since then. I have always admired the work in chemical education which David initiated in York, based solidly within the Department of Chemistry, so that the University of York became the major centre for chemical/science education in the UK. David was very good at getting money out of industry, especially the Salters' Company (a charitable body, a livery company see https://www.salters.co.uk/the-salters-company/company-history/), while retaining full editorial control, and it is this funding that has enabled the international reputation of the University of York in science education. The University of York, and David Waddington, are best known for the suite of context-based courses developed from the early 80s onwards (see Bennett & Lubben, 2006). The work was initially and successfully based in the Department of Chemistry, which became known worldwide as a centre of innovation in Chemistry teaching and learning at both second level and third level.

Table 1: Major events in David's life

1932	Born 27th May, Edgware, Mddx.
1956	Teacher at Wellington College; H ead of Chemistry 1960, Head of Science 1962
1957	Married Isobel Hesketh
1962	Recruited by Professor Richard Norman to the new Chemistry Department in the University of York, which opened in 1965
1981-92	President, Education Division, Royal Society of Chemistry (RSC)
1978-2000	Professor of Chemical Education
1977-81	Secretary, IUPACs CTC
1981-86	Chairman, IUPACs CTC
1980s	Start of the Salters' science courses
1983-92	Head of Department of Chemistry
1985-91	Pro-Vice-Chancellor, University of York
1985	Nyholm Medal, RSC
1985	*Teaching School Chemistry* (UNESCO)

1988	Brasted Award, American Chemical Society (ACS)
1990	*Chemistry: the Salters' Approach*
1994	*Salters' Advanced Chemistry*
2000	Retires, Emeritus Professor of Chemical Education
2000-2004	Visiting Professor, IPN, Kiel, Germany
2006	*Making it relevant: context-based learning of science* (with P. Nentwig)
2012	ACS-CEI award - sustainability in chemical education

His career in chemical education

David Waddington was educated at Marlborough College, and then read Chemistry at Imperial College London (BSc 1953), followed by a PhD (1956). Like Alex Johnstone, PoSE #10, David Waddington started his career as a schoolteacher. From 1956-1964 he taught chemistry and was Head of Chemistry and then Head of Science at Wellington College, a prestigious private school. He was recruited from this by Professor Sir Richard Norman, who was setting up a new Department of Chemistry at the University of York (founded 1965), an unusual but very successful appointment. David Waddington has described how he came to move to York (Waddington, 1993).

"I met Dick Norman in 1959. I was a schoolteacher who had written a textbook, and was urged by a friend who had been taught by him to seek his advice. He came over to visit my wife and myself for a 'quick cup of tea' and a discussion of the book. He left after breakfast the next day and our friendship had begun. When the first Vice-Chancellor at York University, Lord James of Rusholme, was looking for a founder for the Department of Chemistry, Norman's name was in the frame and he was appointed in 1962, before his 30th birthday.

One of his first actions was typical: he wanted me to come with him. Although the appointment of a schoolteacher seemed bizarre, his experience at Oxford had taught him how important relationships between schools and universities were. I was, in turn, excited by his vision, for he was determined not to follow the line taken by many of the universities at that time, having sub-disciplines each with its own Chair, its own empire. We were to be a seamless whole; we were simply chemists. He was determined too to reap the benefits of the single subject, studying Chemistry in depth while at the same time ensuring that students appreciated the burgeoning areas such as biochemistry and chemical physics. Later still, under his influence, the department chose even wider horizons, covering, for example, industrial economics and environmental Chemistry, long before it was fashionable to do so. At the same time, he brought to the department the best attributes of Oxford, including its tutorial system."

David Waddington was to turn out to be one of Professor Dick Norman's most inspired appointments. From the beginning the new Department had a strong emphasis on chemical education, not just on Chemistry, and Chemistry was seen as a single subject, not as disconnected sections, which was then the traditional university view. Thus the University of York became a pioneer in third-level as well as in second-level chemical education. The first 50 years of the Department were described in a commemorative book produced in 2014, with several contributions by David, especially pp 74-85 on chemical education.

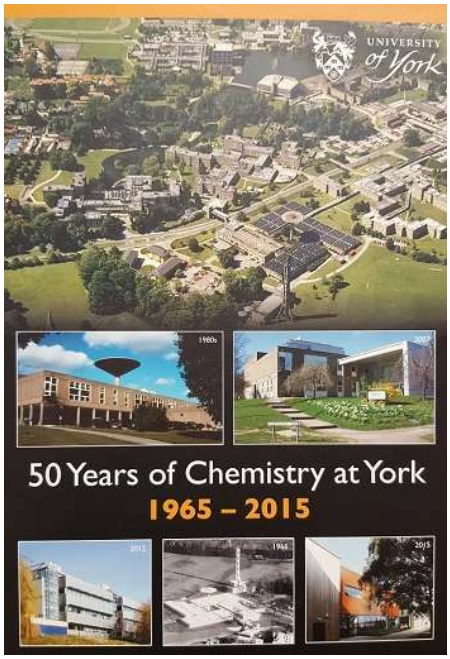

Figure 2: 50 years of Chemistry at York (York, 2014)

Science education at the University of York

Chemical education activities in the Department of Chemistry started soon after it was opened in 1965 and the first Schoolteacher Conference ran in 1966. This led to further conferences and residential courses funded by the Salters' Institute and leading chemical companies.

The James Report of 1972 on teacher education had recommended in-service education for teachers, now referred to as continuing professional development (CPD). An early initiative on chemical education in York followed on from this - a term-long residential course for Chemistry teachers, as part of a Master's course in Chemistry and Chemical Education. This was the start of a fruitful relationship with the Salters' Company, one of the ancient livery companies in London. This was due to Richard Norman's connections with Salters', and marked the start of the Salters' Company's many activities in science education. A small group of Chemistry teachers, funded by grants from the Salters' Institute, and later other companies, came to York for a residential term (Part 1) and then over the next 2 terms (Part 2) completed a school-based research project. The courses involved lectures in Chemistry and Chemical Education. The course ran from 1974 until 1989 and over 100 teachers took part. Many of them returned to York later to work on the Salters' curriculum projects. Declan Kennedy (UCC), Randal Henly and Philip Matthews (ex TCD) all attended this course.

David was instrumental with John Garrett (a biochemistry lecturer) in helping start the University York Science Education Group (UYSEG), and was its first director; this involved people in teacher training and also staff in science departments. One of the strengths at York has been the active links between the education and science departments. The UYSEG is still flourishing and is active in science education research, however, it is now based in the Department of Education not in Chemistry. (See https://www.york.ac.uk/education/research/uyseg/)

When David retired the Salters' Institute provided extra funding to convert a promised lectureship into a professorship of chemical education based in the Department of Chemistry. The first Professor was Sir John Holman. Prior to this John Holman had been a successful Chemistry teacher, headmaster and a Director of the Salters' A-level Chemistry team. The

chair ended up in Education and the current Salters' Professor of Science Education is Judith Bennett (see her remarks below.)

The many activities coming out of the Department of Chemistry (see below) were almost certainly a contributing factor in York being chosen in 2005 as the location for the National Science Learning Centre. Its first Director was Sir John Holman.

The first curriculum materials were developed in the early 80s with a series of case studies on the chemical industry and some case studies to support the Granada Television series *Chemistry in Action*. The units were developed by a team of teachers, academics and industrialists and were a forerunner of both the Salters' context-based courses and the Chemical Industry Education Centre (see later).

Salters' science projects

"The Salters' Institute [see Box 1] began working on curriculum development [from 1983]; the most far reaching change of direction it has made. This change, instigated by David Waddington, Professor of Chemical Education at the University of York, was to bring about a much larger concept – a range of new science courses at GCSE and A Level based on teaching science in context. This is known as 'The Salters' Approach'. The courses focus on the use of chemistry and other sciences in real life, with an emphasis on practical chemistry. The Salters' Approach has been taken up in many other countries with resources written in several different languages." (https://www.saltersinstitute.co.uk/history/)

The work for which the University of York and the UYSEG is most famous worldwide, largely due to the leadership of David Waddington, is the suite of Salters' science courses. The following section is taken from the UYSEG website, showing their current activities.
"The Salters' Institute and the University of York Science Education Group (UYSEG) have worked in partnership for over thirty years, developing innovative teaching materials in order to improve teaching and learning in secondary school science. Materials developed by UYSEG have been adopted in a number of countries.

The Institute and UYSEG currently have five active projects. There are three Advanced level (A level) courses: Salters Advanced Chemistry, Salters Horners Advanced Physics and Salters-Nuffield Advanced Biology, and one course at GCSE level, Twenty First Century Science. The most recent project is Best Evidence Science Teaching (BEST) for lower secondary school students (aged 11-16).

Best Evidence Science Teaching (BEST) is being developed over the period 2016-22. It draws on the best available research evidence on teaching and learning in school science, and provides teachers with a practical means of using research evidence in their teaching. BEST incorporates research on promoting effective learning in science, on assessment, on practical work, on teaching difficult ideas in science, and on engaging students with the science they are studying. BEST also provides a high level of teacher support.

Further information on all the projects may be found on the UYSEG website at www.york.ac.uk/education/research/uyseg/projects/"

Box 1: The Salters' Institute and science education
https://www.saltersinstitute.co.uk/

The Salters' Institute was founded in 1918 as an offshoot of the Salters Company, an ancient London livery company, and it initially funded research fellowships in Chemistry for soldiers returning from WWI.

In the 1970s it started to support initiatives at the University of York for schoolteachers – Chemistry conferences and then bursaries for the Master's in Chemistry and Chemical Education. In 1983 The Salters' Institute began supporting curriculum development in science; the most far-reaching change of direction it has made. This change, instigated by David Waddington, Professor of Chemical Education at the University of York, was to bring about a much larger concept – a range of new science courses at GCSE and A Level based on teaching science in context. This is known as 'The Salters' Approach'. The courses focus on the use of Chemistry and other sciences in real life, with an emphasis on practical Chemistry. The Salters' Approach has been taken up in many other countries with resources written in several different languages.

Other science activities of the Salters' Institute include

- Chemistry Camps
- Festivals of Chemistry
- The Chemistry Club
- National Awards for Science Technicians

This now world-famous initiative In York to develop context-based science courses goes back to the early 80s (Bennett & Lubben, 2006), and a dissatisfaction with existing science curricula and their lack of appeal to students. It was sparked by John Lewis's Science and Society course in the 1970s and his conference on this topic in Bangalore, attended by David Waddington. The first planning meeting was held in 1983 and at this meeting it was decided to develop a suite of context-based Chemistry units for junior secondary students, which became *Chemistry- the Salters' Approach*; it was based around 16 units over 3 years.

"The Salters' chemistry course was designed as a three-year course for the 13-16 age group. It consisted of 16 teaching units. There were five units for the first year of the course: Clothing, Drinks, Food, Metals, and Warmth. These were accompanied by a textbook called Introducing Chemistry: The Salters Approach.
The seven units provided for the second year of the course were entitled: Buildings, Food Processing, Growing Food, Keeping Clean, Minerals, Plastics and Transporting Chemicals. For the final, GCSE year, there were four units: Burning and Bonding, Energy Today and Tomorrow, Fighting Disease and Making and Using Electricity. A second textbook was published to cover the whole of the GCSE course."

"If longevity is one mark of impact, then the notion of using contexts as the starting point for the development of scientific understanding must be one of the major movements in science education of the last part of the twentieth century." (Bennett & Lubben, 2006, p. 999)

The initial and main funding came from the Salters' Institute and so they became known as the Salters' courses. Each curriculum project cost around £1 million to run, and David Waddington was mainly responsible for raising the money. This must be counted as one of his major achievements, which has resulted in a major science curriculum reform. The review

paper by Bennett & Lubben (2006) focuses on one of the six Salters' courses, the A-level Chemistry course. The six courses, their age range and dates are given below.

- Chemistry: the Salters Approach (for students aged 14–16, developed in the mid 1980s);
- Science: the Salters Approach (for students aged 14–16, developed in the late 1980s);
- Salters Science Focus (for students aged 11–14, developed in the early 1990s);
- Salters Advanced Chemistry (for students aged 17–18, developed in the early 1990s);
- Salters Horners Advanced Physics (for students aged 17–18, developed in the mid to late 1990s);
- Salters Nuffield Advanced Biology (for students aged 17–18, currently under development).

These courses started from a suitable context and developed the science needed to understand that context. The A level Chemistry courses was built around 11 themes, later restructured into AS and A2 courses, and now back to a 2-year course.

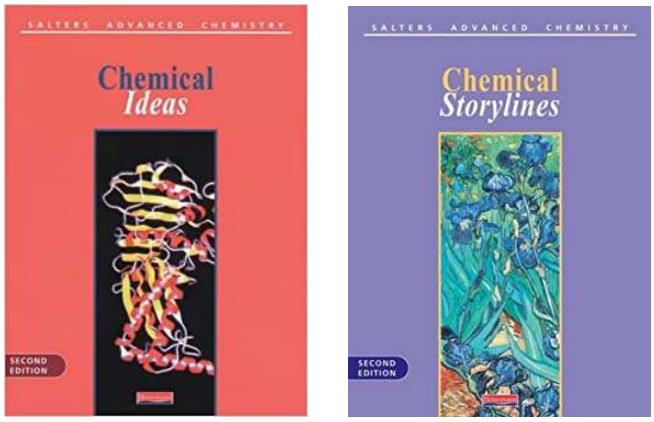

Figure 3: Two books from Salters Advanced Chemistry course

The current 2-year A-level Chemistry course has 10 context-based units:
Elements of Life, Developing Fuels, Elements from the Sea, The Ozone story What's in a medicine, The Chemical Industry, Polymers and life, Oceans, Developing materials, Colour by design.

The Salters Science Course (1992-2007) was replaced by the successful *Twenty-First Century Science* Course (see below), using many of the same ideas and approaches. However, neither the Salters' courses nor *Twenty-First Century Science* were introduced without controversy or opposition from both science educators and scientists. They have, however, stood the test of time and succeeded in the marketplace of science curricula.

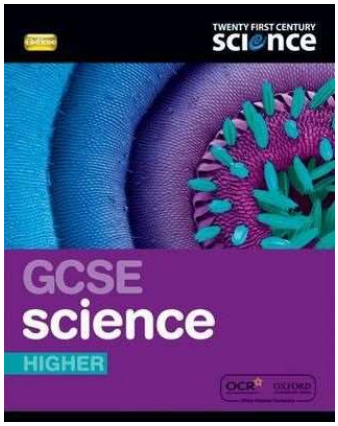

Figure 4: 21st Century Science

"Twenty First Century Science is an innovative suite of GCSE science courses studied predominantly by students aged 14-16. Trials for the course began in 75 schools across England and Wales in September 2003 with the first examinations sat in June 2004. The Twenty First Century Science course has been available nationwide since September 2006. This course was developed as a joint project between the University of York and the Nuffield Foundation Curriculum Programme, with funding from the Nuffield Foundation, the Wellcome Trust and The Salters' Institute.
The course aims to develop scientific literacy for all students by teaching key science explanations and an understanding of the nature of science ensuring that students should be prepared to engage with scientific debate and decision making in their daily lives. It also helps prepare the next generation of professional scientists by providing students seeking this route with a firm basis for future study."

The Salters' science courses have had an impact outside the UK, either by direct adoption and translation, customising for local markets by adaptation, or by encouraging new courses, like *Chemie im Kontext*, based on the Salters' Model. *Chemie im Kontext* is a German context-based Chemistry course, initiated by Professor Ilka Parchmann (IPN, Kiel), after spending a year in York in 1997 (see her remarks below) and was based on science education research findings. Other versions have been published, *inter alia,* in Sweden, Slovenia, USA and Russia, some by adaptation, others by direct translation.

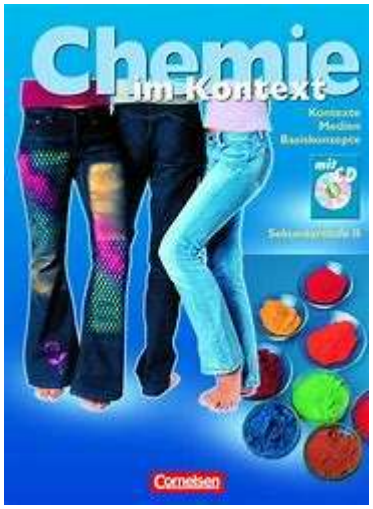

Figure 5: *Chemie im Kontext*: Chemistry in a German context

CENTRE *for* INDUSTRY
EDUCATION COLLABORATION

Chemical for Industry Education Collaboration (CIEC)

http://www.ciec.org.uk/
A logical development from the early case study work and the context-based curricula was to create more links with industry and provide information about the chemical industry to schools. This led to the setting up of the Chemical Industry Education Centre (CIEC) in 1988, a joint venture with the Chemical Industries Association (CIA). The first Manager was a local Chemistry teacher, Miranda Stephenson, who in 2004 moved on to become Asst. Director of the National Science Learning Centre (now the national STEM Learning Centre). CIEC has been very successful in building links with industry and in producing over 100 industry-related curriculum materials. David Waddington was the driving force behind the new centre and was responsible with Miranda for raising the funds from several science-based firms. Over the years CIEC has produced many teaching resources (Figure 6). It is worth noting *The Essential Chemical Industry*, first published in 1985, edited by David Waddington and John Lazonby, and since 2013 available as a web version at https://www.essentialchemicalindustry.org/.

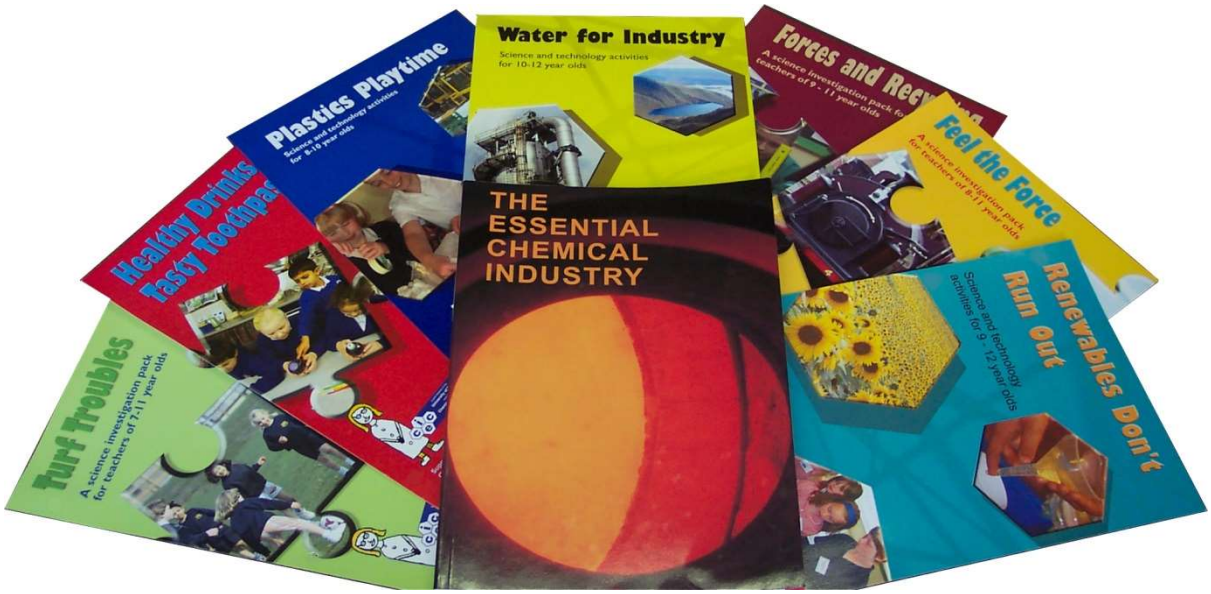

Figure 6: Some of the 100+ publications from CIEC (Source:CIEC, University of York)

In 2004 the CIEC changed its name from the Chemistry Industry Education Centre to the Centre for Industry Education Cooperation, to reflect a broader brief than the chemical industry. It is still located in the Chemistry Department at York, and has benefited greatly from interactions with Chemistry staff, and staff in other science departments.

Chemistry Review

Figure 7: The cover of *Chemistry Review*

The University of York, through UYSEG, is also the home of a stable of science titles for secondary schools, the first of which was *Chemistry Review*. Publication started in 1991, now with 4 issues a year, aimed at second level students and was first edited by the late John Garrett. It is available from Hodder & Stoughton and volume 30 was published in 2020/21. (https://www.hoddereducation.co.uk/subjects/science/products/general/chemistry-review-magazine-volume-30,-2020-21) There is also a *Physics Review* and a *Biological Sciences Review.*

Connections with Ireland

In 1979 Peter Start of UCD's Chemistry Department brought the 5th International Conference on Chemical Education (ICCE) to Ireland, and it was hosted in Trinity College. The ICCE conferences were organised by the Chemistry Teaching Committee (CTC) of IUPAC, and at this time David Waddington was the secretary of CTC. I had a poster at this conference on a teachers' newsletter I had produced in Uganda, and an Irish teacher suggested I start something similar in Ireland – that was the impetus for *Chemistry in Action!* I had been in touch with David before this, and had organised for him to be external examiner (1981-83) at Makerere University, Kampala, Uganda, where I had worked 1970-76. This contact with David also meant that from 1976-77 I spent a year in the Chemistry Department at York, on a resettlement fellowship after coming back from Uganda. I have kept in contact with David since then and count him as a good friend and mentor.

Declan Kennedy, whilst still a schoolteacher, did the one-term residential course in Chemical Education at York as part of the Master's in Chemistry and Chemical Education, where he met David Waddington. This led to Declan doing his PhD part-time at York, supervised by Judith Bennett. As a result of this David has been a frequent visitor to UCC as an external examiner for Declan's students and as a speaker at the BASF Summer Schools. (See Declan's remarks below.) David was also external examiner for Philip Matthews' MEd course at Trinity College, and Philip was also a graduate of the MSc course at York. There is thus a strong York-Ireland connection through David.

Figure 8: David Waddington speaking at ChemEd-Ireland 2011 (Photo: P.E. Childs)

David Waddington also spoke at ChemEd-Ireland in 2001. In fact, over the years five people from York have spoken at the ChemEd-Ireland conferences in Limerick (published in *Chemistry in Action!* the following year):

- Francesca Garforth (1986) (Garforth, 1986)
- David Waddington (2001) (Pilling & Waddington, 2002)
- Anne Hodgson (2003) (Hodgson, 2004)
- Judith Bennett (2004) (Bennett, 2005)
- John Holman (2006) (Holman, 2007)

The GCSE course 21st Century Science was also developed by the UYSEG at York and in 2005 Andrew Hunt spoke about the course at ChemEd-Ireland. (Hunt, 2006)

International activities

The International Union of Pure and Applied Chemistry (IUPAC) is the international body linking national chemical societies. It has an active committee in chemical education, initially called the Committee for the Teaching of Chemistry (CTC) and now the Committee for Chemical Education (CCE). This committee organises an International Conference on Chemical Education (ICCE) every two years, and when I first met David, he was the secretary (1977-81), later chairman (1981-86), of this committee. He was also secretary (1986-89) and chairman (1990-94) of the Committee on the Teaching of Science of the International Council for Scientific Unions (ICSU). These positions were a measure of his international reputation, and they also gave him contact with chemical educators around the world. He was involved in an IUPAC project from 1979 in organising workshops and publications about producing Low-Cost Equipment, with Krishna V. Sane of India. (Sane, 1987) David also initiated the writing of the book *Teaching School Chemistry* (Waddington, 1984), published by UNESCO.

The University of York is a great venue for conferences and several successful international conferences have been held in York, organised by David and his team:

- 11th International Conference on Chemical Education (ICCE) 1991
- 1st Industry-Education Initiatives in Chemistry (with CEFIC) 1995
- 4th European Conference on Research In Chemical Education (ECRICE) 1997
- 5th European Education-Industry Partnership conference 2000

I think I was at all of these and I especially remember the receptions and banquet held in the National Railway Museum. The popularity of these conferences both indicated the importance of chemical/science education at York, but also extended its international reputation and influence.

Publications

David Waddington has been very active in publishing books and articles in chemical education, in addition to the Salters' course materials. Some of these publications are listed below and all are worth reading.

- *Organic Chemistry*, 1962, 4th edn 1969;
- *Organic Chemistry Through Experiment*, 1965, 4th edn 1985 (with H. S. Finlay);
- *Modern Organic Chemistry*, 1972, 4th edn 1987 (with R. O. C. Norman);
- *Chemical Education in the 70s*, 1980 (with A. Kornhauser and C. N. R. Rao);
- *Teaching School Chemistry*, 1985 (ed);
- *The Essential Chemistry Industry*, 1985, 5th edn 2011 (with John Lazonby) (now online at http://www.leck.co.uk/demo/eci3/);
- (ed) *Education, Industry and Technology*, 1987;
- *Introducing Chemistry: the Salters' approach*, 1989 (jtly);
- *Chemistry: the Salters' approach*, 1990;
- *Salters' Advanced Chemistry*, 1994, 2nd edn 2000 (jtly);
- *Science for Understanding Tomorrow's World*: global change, 1994, 2nd edn 2000, (ed);
- *Global Environmental Change Science: education and training*, 1995;
- *Partners in Chemical Education*, 1996 (with J. N. Lazonby);
- *Making a Difference: Evaluation as a Tool for improving Science Education*, 2005;
- *Making it relevant: context-based learning of science* (with P. Nentwig, eds)
- *Making it Comparable: Standards in Science Education*, 2007 (with P. Nentwig and S. Schanze, eds)

Other initiatives from the Department of Chemistry at York

York has been a leading light in chemical education nationally and internationally, at second level, but also at third level. David Waddington has not been involved in all these activities but he was part of the supportive climate in which educational initiatives could flourish, especially during in his term as Head of Department (1969-1973). He was ably aided by the late John Garrett, a biochemist, who initiated the annual series of Variety in Chemistry Education (ViCE) conferences at York in 1993. These are now run, jointly with the Variety in Physics Education conference (merged in 2000), by the Royal Society of Chemistry and the Institute of Physics. The aim of the Variety meetings, which were annual, two-day residential meetings, was to bring together university Chemistry lecturers to share ideas on teaching and learning Chemistry at third level. One of its memorable features was to combine a drinks reception with the poster session. ViCE ran in York for many years but now moves around different universities in the UK. An Irish Variety in Chemistry Education (IViCE) was started a few years ago by Bill Byers and Peter Childs. A European conference,

EuroVariety, was started in 2005 and is now held every two years, alternating with ECRICE. It is organised by the Division of Chemical Education of EuCheMS. These 'Variety' conferences have had a major influence in improving teaching and learning in Chemistry at third level in the UK, Ireland and Europe, and have encouraged more Chemistry third-level academics to get involved in Chemistry education research (CER).

The University of York Chemistry Department has also been a pioneer in Green Chemistry and Green Chemistry Education, Environmental and Sustainability Education. The Department through David Waddington and others in the CIEC was awarded an ACS-CEI award for Incorporation of Sustainability into Chemistry Education in 2012. The citation is given below.

Teaching Sustainability: 40 Years of Experience
The University of York's Chemistry Department has been teaching and developing curriculum materials addressing sustainability of over four decades. This curriculum-development work began within its own undergraduate courses and now encompasses instructional materials impacting primary (K-6) and secondary (7-12) education, undergraduate, postgraduate teaching, and outreach activities for the general public. This is all based within two groups that conduct high quality chemistry and education research—the Green Chemistry Centre of Excellence and the Chemical Industry Education Centre. Both share three common features:

- *Embedded within the teaching of chemistry at the appropriate level;*
- *Based on contemporary educational practice and informed by research;*
- *Developed so that the materials can be implemented, with appropriate adjustments, within other nations.*

(https://www.acs.org/content/acs/en/about/governance/committees/cei/sustainability-in-the-curriculum/award-for-incorporation-of-sustainability-into-chemistry-education-2012.html)

Some personal appreciations:

From Professor Judith Bennett
Salters' Professor of Science Education, University of York

David was instrumental in setting up the University of York Science Education Group (UYSEG) and his leadership in the first fifteen years helped establish the group's reputation as a national and international centre for innovation and research in the teaching of science in schools. Crucial to the success of UYSEG was the partnership David established with the Salters' Institute. The shared vision of making a difference for the better to the experiences young people have in their school science lessons enabled UYSEG to develop highly successful curriculum courses and resources that were adapted and adopted in many countries. David has influenced school science education nationally and internationally in many ways. One of his most enduring legacies is that of teaching science through its contexts and applications. While this might seem an obvious thing to do now, it was very novel in the 1980s and 1990s. He has also shown that it is possible to bring about significant change in classroom practice if you develop materials that translate general principles into resources that teachers can use in their lessons with their students - and involve teachers in the development process. This was important at the time and is even more so today when universities are under huge pressure to demonstrate how their work has an impact on society. Finally, and in a less obvious way, I know that many of the people who worked with David would say that they have learned much about leadership from him. David has the ability to make people believe that they are exactly the right person to be doing the job that they are doing, and this trust and confidence has enabled people to do their very best to improve young people's experiences of science.

From Professor Ilka Parchmann, IPN Kiel, Germany

Without David I would not be in my current position as Professor for Chemistry Education at Kiel University and Head of the department of Chemistry Education at the Leibniz Institute for Science and Mathematics Education (IPN). He did not only inspire me with regard to setting up a context-based learning program similar to Salters' in Germany, but he also gave us wonderful advice in how to realize it, and how to incorporate teachers as well as chemists. He inspired teachers and co-workers during his stays in Kiel as Visiting Professor. During my visits in York he enabled so many different insights into programs and structures that are highly relevant for my own work up to today! And he has always been and still is a good friend to chat with, as well as his wife. Very fascinating characters!

I first went to York on a German scholarship for a three months Post-Doc in 1997. I studied Salters' Chemistry and other approaches to context-based learning both in the UYSEG and in school practice. This led to the development of *Chemie im Kontext* (CHiK) in Germany. How successful has CHiK been? This depends on what you count as success. The nationwide standards in science education as well as the state-related curricula and textbooks have all integrated the idea of context-based learning. The first Cornelsen textbook, however, has not survived. We will now reproduce it as OER to relaunch the approach! To my point of view, it has been successful, and it has certainly influenced the chemistry education world as well.

From Dr Declan Kennedy, University College, Cork

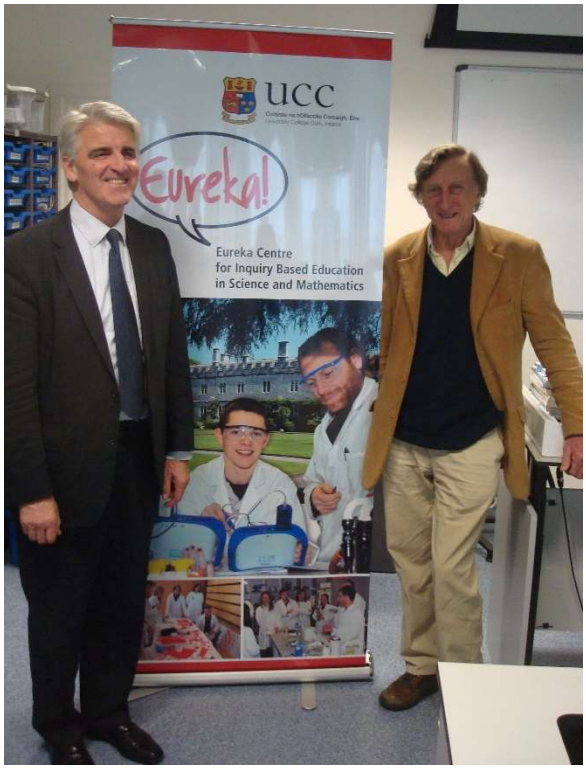

Figure 9: Professor David Waddington and Professor Pat Fitzpatrick, Head of College of SEFS, in UCC. In his role as external examiner, David advised UCC on the setting up of the Eureka Centre.

I first met David Waddington in January 1986 when I attended the Association for Science Education Annual Conference at the University of York. I attended a talk given by David in which he spoke about the work of the University of York Science Education Group (UYSEG) and also mentioned that he was the director of a three-month residential continuing

professional development programme for science teachers. I was then a young science teacher, with just a few years teaching, and I felt that this course would be a great help to me for my future teaching career. The course was also highly recommended by Randal Henly, who had attended the course a few years earlier. In January 1987 I applied for leave of absence for three months from my school and headed off to York. The course at the University of York was the most outstanding CPD programme that I ever attended. The fact that David was a former secondary school teacher of chemistry was a huge advantage as he clearly understood the needs of practising chemistry teachers.

I returned to Ireland from York bubbling over with enthusiasm about the work being done by David and his team. At that time, I was a member of the NCCA committee that was working on the 2000 Leaving Certificate chemistry syllabus. I recall bringing along to the syllabus committee meetings many of the Salters' publications from the University of York. The context-based approach or science technology and society (STS) approach (as it is more commonly known in Ireland) to teaching chemistry that was developed in the University of York, was hugely influential in the Leaving Certificate chemistry syllabus that was published in 2000. In particular, the syllabus committee was very impressed with the approach to teaching Organic Chemistry starting with the topic of fuels and emphasising mechanisms of organic reactions throughout this part of syllabus. The excellent quality of the 2000 Leaving Certificate chemistry syllabus is evidenced by the fact that it was warmly received by chemistry teachers throughout Ireland, has been very successfully implemented in the classroom and brought about an increase in the number of students studying Leaving Certificate chemistry. The importance of incorporating STS into our teaching of chemistry was emphasised by the introduction of an STS column into the 2020 Leaving Certificate syllabus. Thus, David Waddington had a direct influence on the Leaving Certificate chemistry syllabus published in 2000.

David has also had a huge influence on the quality of training science teachers in Ireland. When I took up a teaching position in University College Cork, one of the first projects that I undertook was the setting up of a BSc Science Education programme and a Masters' in Science Education programme. The Masters' programme was modelled on the excellent programme that David ran in York and I had no difficulty in persuading Professor Áine Hyland, then Professor of Education, to appoint David as the external examiner for both this programme and our BSc Science Education programme. Thus began the many trips to Ireland of David and his lovely wife Isobel. David would come with me to visit the students on teaching placement, while Isobel would visit the local art galleries and Ballymaloe café!

As external examiner, David made an enormous contribution to science education in University College Cork. He gave his full support to setting up the Eureka Centre in UCC, which is modelled on the facilities that David has for the University of York Science Education group: science education laboratories, resource centre, lab preparation room and a seminar room. Professor Pat Fitzpatrick, Head of College of Science, Engineering and Food Science, travelled over to see the facilities that David had in York and agreed that we needed to set up something similar in Ireland to train science teachers and to provide CPD to practising science teachers. David has visited the Eureka Centre on many occasions to speak at ISTA conferences and summer schools for chemistry teachers.

Words cannot express the enormous debt of gratitude that Ireland owes to David Waddington for his huge influence on curriculum design and his enormous contribution to training science teachers in Ireland. Sincere thanks to David for all that he has done for science education in Ireland. May the Lord continue to bless him and Isobel with good health and happiness.

Conclusion

I hope this article has made the case for considering David Waddington as one of the Pioneers of Science Education worldwide, not just in the UK, especially because of the international influence the Salters' context-based science courses have had on science curricula. Professor Dick Norman's inspired choice of David to join the new Department of Chemistry at York has had a major impact on the work of the department: its contact with schools and teachers, through conferences and the Masters' course; the innovations in teaching and learning in the Department; the setting up of the CIEC to link industry and education; the publications for teachers, including *Chemistry Review*; the setting up of the UYSEG to promote not only curriculum development but also science education research.

David Waddington would be the first person to give others the credit, as his article in the booklet *Fifty Years of Chemistry at York: 1965-2015* shows. David was also active in teaching Chemistry, doing chemical research in kinetics at York, and in administration. One could say that he has been a remarkable catalyst for initiating activities in chemical education at York. He provided the drive and enthusiasm to get projects started, to recruit teachers and academics to work on the projects, and most importantly, to build contacts with industry to raise the funds to enable the projects to succeed.

It is not too much to say that the Salters' suite of science courses represents the most successful and influential curriculum development project ever. This is based on the number of courses, the length and level of the courses (from 5 to 2 years, at junior and senior secondary level, in all the sciences), the range of teaching materials produced, the sizable adoption by schools in the UK, and its worldwide impact through translation, adaptation and inspiration. The only comparable curriculum development project would be the Nuffield projects in the 60s and 70s. The US Chemistry projects – ChemStudy, Chemical Bond Approach, ChemCom, and Chemistry in Context, were also important but have had less impact globally due to the nature of US education system, which made them less universally applicable. (See Heikkenen & Waddington (2015) for a detailed survey of these UK and USA curriculum projects in Chemistry.)

David was also a great encourager of young teachers and academics, like me and Declan Kennedy, and he has created a worldwide network of friends. He raised the funds and created the teams that developed the Salters' projects, and I think it is true to say that without David, they wouldn't have happened, nor would they have been so successful.

David Waddington was also active in promoting chemical education internationally, especially through IUPACs CTC, and through UNESCO. In particular, he helped promote workshops and publications about low-cost equipment for teaching science, especially in developing countries.

It was said of Humphry Davy that his most important discovery was Michael Faraday. Perhaps it is not too much to say that Professor Sir Dick Norman's most important act was to recruit the young schoolteacher, David Waddington, to the new Department of Chemistry at York. **The rest, as they say, is history.**

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