Chemical Education in Europe

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CHEMICAL EDUCATION

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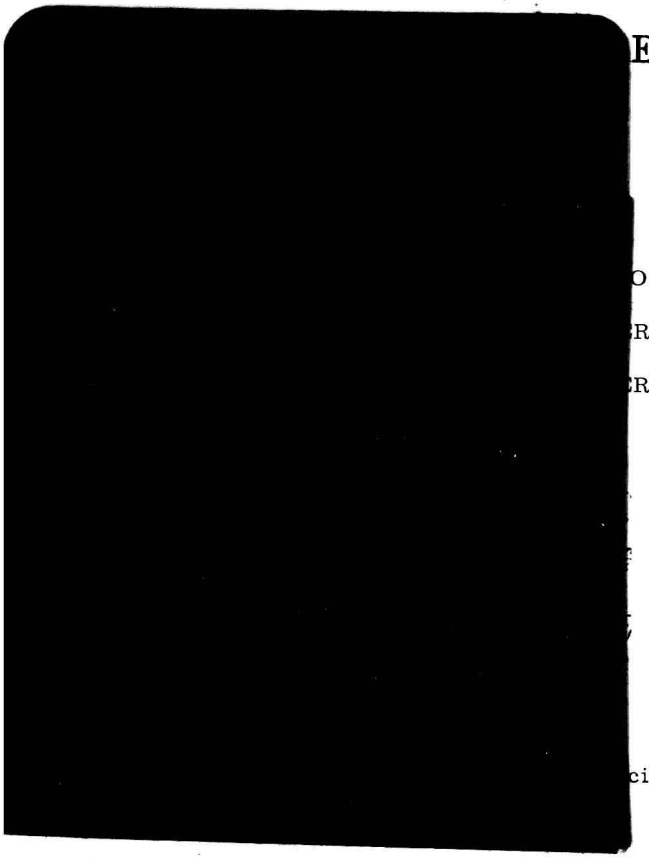

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Finally we must thank the Société Chimique de France and the Gesellschaft Deutscher Chemiker and the Union of Yugoslav Chemical Societies for making it possible for one of us (SDW) to work for periods in France, the Federal Republic of Germany and Yugoslavia.

We also greatly appreciate the help of Ann Aldred, Deborah Bowes, Margaret Livock and Christine Newton for secretarial assistance.

The information in this book is as accurate as possible at the time of printing, November 1976. We apologize for any mistakes and we would be grateful if readers would inform us of errors of omission and commission, and of relevant changes in their national educational system. All appropriate amendments will be incorporated in subsequent editions.

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FOREWORD

The idea of this book was conceived by the late Professor J.W. Linnett of the University of Cambridge. He suggested to the Education Division of the Chemical Society that just as science is international so is science education, and therefore chemists and chemical educators in Europe should have a resource book about the teaching and learning of chemistry in their various countries. He hoped that such a book would lead to more understanding and would promote exchanges both of ideas and personnel. Each country in Europe has something to learn about chemical education from another, but there are difficulties because of the barriers arising from our diverse languages, traditions and educational systems.

In 1974 the Chemical Society, with financial assistance from the Royal Society decided to act on Professor Linnett's suggestion and to establish the project which has now led to this publication. Professor J.W. Linnett (Chairman until November 1975), Drs. W.J. Barrett, W.B. Moyes and R.E. Parker and I acted as an Advisory Committee to the editors. We are grateful to the Working Party on Chemical Education of the Federation of European Chemical Societies for much enthusiastic support and to UNESCO for financial assistance at several stages.

We dedicate this book to Jack Linnett and we hope, as he would have wished, that by lowering the barriers to understanding it will help to develop chemical education in Europe and to promote the movement of chemists across national boundaries.

C.C. Addison
President, The Chemical Society

November 1976.

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Compiled by M.J. Frazer and S.D. Walker

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A General Survey

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The purpose of this introduction is to give an overview of chemical education in Europe and to provide a guide to the structure of this book.

The book is a result of a project sponsored initially by the Working Party on Chemical Education of the Federation of European Chemical Societies and financially supported partly by UNESCO, but mainly by the Chemical Society and the Royal Society, London. The purpose of the project was (i) to inform chemists of the level and significance of the various chemical qualifications in Europe, (ii) to contribute to understanding between the various national educational systems and (iii) to stimulate innovations in the teaching of chemistry by exchanging ideas and comparing practices. All the countries of Europe are included, except those listed on page 173, which in the main do not have developed systems of higher education. The project covered chemical education at school and university level as well as the training of chemistry teachers.

There are two parts. For Part I we invited twelve chemists each with different teaching and research experience in more than one country to write freely about some aspect of chemical education. Their contributions are as varied as is the geography and history of our continent but they each provide a glimpse of what it is like to teach or learn chemistry in contemporary Europe. It was impossible to invite someone from every country to contribute an article but we hope that any gaps are corrected by Part II which is a factual and comprehensive account of chemical education in Europe.

Information for Part II was collected by: (i) using existing publications (see the bibliography, page 375), (ii) correspondence and interviews with leading chemical educators in Europe, (iii) visits to a number of countries, and (iv) a questionnaire circulated to teachers, government officials and educators in each country. As the information was built up, drafts of the survey were circulated in each country for checking, correcting and supplementing. Part II is therefore as accurate as it could be and should be taken to refer to 1976.

During the collection of the data for Part II we asked our correspondents to identify contemporary problems and innovations in their countries. In this first article I shall highlight some of the trends which became apparent.

It is always dangerous to generalize, but to generalize about something as complex and diverse as education in Europe might be considered foolhardy. There are, therefore, exceptions to all the statements which follow, nevertheless it is hoped that the remaining paragraphs will give a flavour of what it is like to be trained as a chemist in Europe.

What are the general patterns of education?

Tables 1 and 2 summarize the overall structure of chemical education. Starting at the age of five or six there is commonly compulsory education for about ten years. A minority stay at secondary school for a further two or three years. Most countries have systems of part-time education for early school leavers. Usually the courses are vocational and for chemistry lead to careers such as laboratory assistants, and plant operators. It is important however that such education should not be restrictive and most countries, at least in theory, have mechanisms to allow late developers to move into university education. Provision of technical and vocational education usually on a part-time basis extends well beyond the school leaving age. We have not surveyed this aspect of chemical education in any detail but the

highly developed system in the German Democratic Republic, with its close cooperation with industry, might serve as a model.

In most European countries there is some form of military service and this sometimes means that university entrance is delayed. There are three phases of university study. The first lasting from between three to five years leads to a first degree or diploma. This can then be followed by study involving a large element of original research which leads to a doctoral degree. In some countries there is a well established intermediate level (called Masters degree, Magister, etc.) between the first degree and the doctoral degree. The third phase, which is available only for a very small minority, is the higher doctoral level awarded for distinction in research.

Chemical education beyond school level is considered in most countries as largely vocational, and indeed some countries recognize a specialization during the later stages of the diploma (first degree) study so that students can select courses to prepare them for three types of career: (i) teacher at secondary school level, (ii) chemical technologist in commerce, industry or government service, (iii) research or teacher in an academic establishment or research institute. In translation the English word "lines" is often used to refer to these routes of specialization through the diploma study, and this word is used in this sense in a number of places in this book. In the United Kingdom and a few other countries, it is now accepted that a chemistry graduate may take up entirely non-chemical occupations using chemistry as a vehicle for general education, but this notion is not widely recognized.

In seeking general patterns of chemical education we might ask the questions: "Where and why is chemistry studied?" Table 2 is an attempt to answer these questions with cross references to later sections of the book.

One purpose of chemical education missing from Table 2 is the need for the general public to obtain some knowledge and understanding of chemistry. We discovered as a distinct trend in most countries, a

TABLE 1 Outline pattern of education for a chemistry graduate (a)

Educational Level	Phase	Approximate age range (b)	Examples of titles of qualifications (c)	Section in Part II which gives details
Primary	-	5-12 (d)	-	2 (e)
Secondary	Compulsory	12 (d)-16	General Certificate of Education Ordinary level (UK)	4, 5, 6
	Final	16-19	Baccalauréat (France) Abitur (FDR) Matura (Yugoslavia)	
Tertiary	First degree	19-24	Maîtrise (France) Diplom-Chemiker (GDR) Bachelor of Science (Ireland)	7, 8, 9
	Doctoral or Masters degree (f)	24-30	Doctor (Netherlands) Doctor rerum naturalium (FDR) Kandidat Nauk (USSR)	10
	Higher doctoral degree	35	Doctor of Science (UK) Doctor Philosphiae (Norway)	10

(a) For full details see Part II, Section 2. Technical education and teacher training have been omitted.
(b) The length of courses in any particular country is much shorter (see page 298).
(c) For the complete list see pages 265-271.
(d) In some countries elementary education continues until age 14.
(e) Generally little chemistry is taught at this level but Section 2 gives details of primary education in each country.
(f) For details of Masters degrees see page 335.

TABLE 2 Chemical education - where and why?

Where?	Why?	Article in Part I	Section in Part II
Secondary school	General education for future citizenship and, for a minority, the preparation for further study of chemistry	Thompson Laffitte	2, 4, 5, 6
Vocational (technical) college	Training of laboratory assistants, plant operators etc.	-	2
Pedagogical Institute (College of Education)	Training of school teachers mainly for primary and lower secondary levels	Kornhauser	2, 12
University	1. Training of school teachers mainly for secondary level	Kornhauser	2, 7, 8, 9, 10, 12
	2. Training of chemical technologists for industry, government service	Urbanski Laffitte Illuminati Magat Nord Ross Wotiz	2, 7, 8, 9, 10
	3. Preparation for career in academic research or teaching	Illuminati Nord Wotiz Urbanski	2, 7, 8, 9, 10, 11

University	4. Chemistry as a supporting subject in the education and training of medical doctors, pharmacists, technologists etc.	Bénard Velthorst Urbanski	7, 8, 9 in part
	5. General education for managerial and other "graduate" employment	-	7, 8, 9 in part

recognition of the importance of using schools, colleges, universities as well as the press, radio and television to help the population at large towards an appreciation of the complex chemical issues which in any modern society affect all our lives (from pollution to pure water, from the costs of synthesising new and more versatile materials to the control and testing of new drugs). The Royal Netherlands Chemical Society has been particularly active in this area.

We also found an increasing awareness of the need to establish systems of permanent education for chemists. Our subject is expanding so rapidly that constant updating, and possibly periods of retraining, are considered important. Although there are various schemes no general pattern emerges and we have not included a separate section on this topic.

In Tables 1 and 2 we have used the word "universities" to cover all institutions offering courses at first degree or diploma level (i.e. a minimum of three years full-time study after school level). There are many titles for such institutions (e.g. Technische Hochschule in FDR, Grandes Ecoles in France, polytechnic in the UK) and their traditions and functions are very different. Details are given in section 2 of Part II. The graduates of technical universities in some countries have the title "engineer" (e.g. in France: ingénieur from the Grandes Ecoles). Sometimes there arises the absurd situation of a university and a technical university, both in the same city, both with chemistry departments, both possessing expensive apparatus but neither cooperating fully.

Space did not allow us to mention individual institutions of higher education and readers are referred to the bibliography (see "Directories", page 375).

How can we compare qualifications?

There are dangers in "instant" comparative education, and any real understanding of the meaning of a particular qualification (in terms

of the likely knowledge, abilities, experiences and attitudes of a holder of the qualification* can only be obtained if there is an understanding of the philosophy and structure of the educational system producing it. For this reason Section 2 of Part II contains a diagram, and brief description, of the educational system in each of the countries discussed. It is misleading to compare years of study leading to a university qualification in chemistry without first knowing: (i) the intensity of study during each year, (ii) the teaching and learning methods employed, (iii) the hours of chemistry studied before university and (iv) the intellectual maturity and motivation of the students at the pre-university level. Clearly in a given number of hours much more chemistry will be learnt by selected, well motivated students at the age of 17-18, than by 13-14 year olds studying the subject compulsorily. Tables III, VI, VIII, IX and X in Part II will provide information to enable meaningful comparisons of qualifications.

What curriculum changes have occurred at secondary level during the last decade?

"Curriculum" is not used in the narrow sense of syllabus but should be interpreted to refer to the whole approach to teaching chemistry including aims, teaching methods, subject content of courses and assessment methods. In general Europe was rather slower to change the nature of secondary level chemistry courses than the United States, but following the publications of the CHEM Study books, and in response to the needs and demands of students, teachers and of society in general there has been much curriculum reform. Our survey revealed the following trends: aims of courses are now stated explicitly; recognition that chemistry at secondary level is not concerned only with content aims (i.e. the subject centred approach) but with process aims (i.e, the student centred approach); a slow move away from formal didatic

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* A description of this kind is often referred to as a "profile".

teaching with more use of guided discovery (heuristic) methods; recognition that the content of courses must relate to the way chemistry is used and to the everyday experience of the students; increasing use of projects often with an environmental or industrial chemistry bias; individual learning methods are more frequently used; greater use of films and other audio-visual aids; a growing awareness by teachers and curriculum developers that some chemical concepts cannot be learnt with real understanding by many in a particular age range and that the logical structuring of chemistry for optimum learning is important; greater use of newer methods of assessment such as continuous assessment by the teacher, fixed response items, etc. We also discovered a great deal of interest and a few experiments of combining the teaching of chemistry with that of the other sciences to produce, at least to the age of 16, integrated science courses.

Who is responsible for curriculum reform?

There are many different agencies. The answer to this question depends very much upon the traditions and educational system of the country concerned. Many countries have a strong central control of the curriculum from the Ministry of Education. Readers may obtain details of the agencies of curriculum reform by reference to Part II: sections 2 and 5 (for secondary level); and section 8 (for university level). A number of countries, conscious of the importance of science education, have established special commissions; for example in France there is the Commission Lagarrigue established in 1971 with the task of improving teaching of physical sciences in secondary schools.

Although universities are generally responsible for their own curricula, there are laws in several countries which slow down the process of reform. Professor Illuminati's article illustrates this situation. However the survey clearly revealed that in all countries new curricula were being introduced or existing programmes were being improved and updated.